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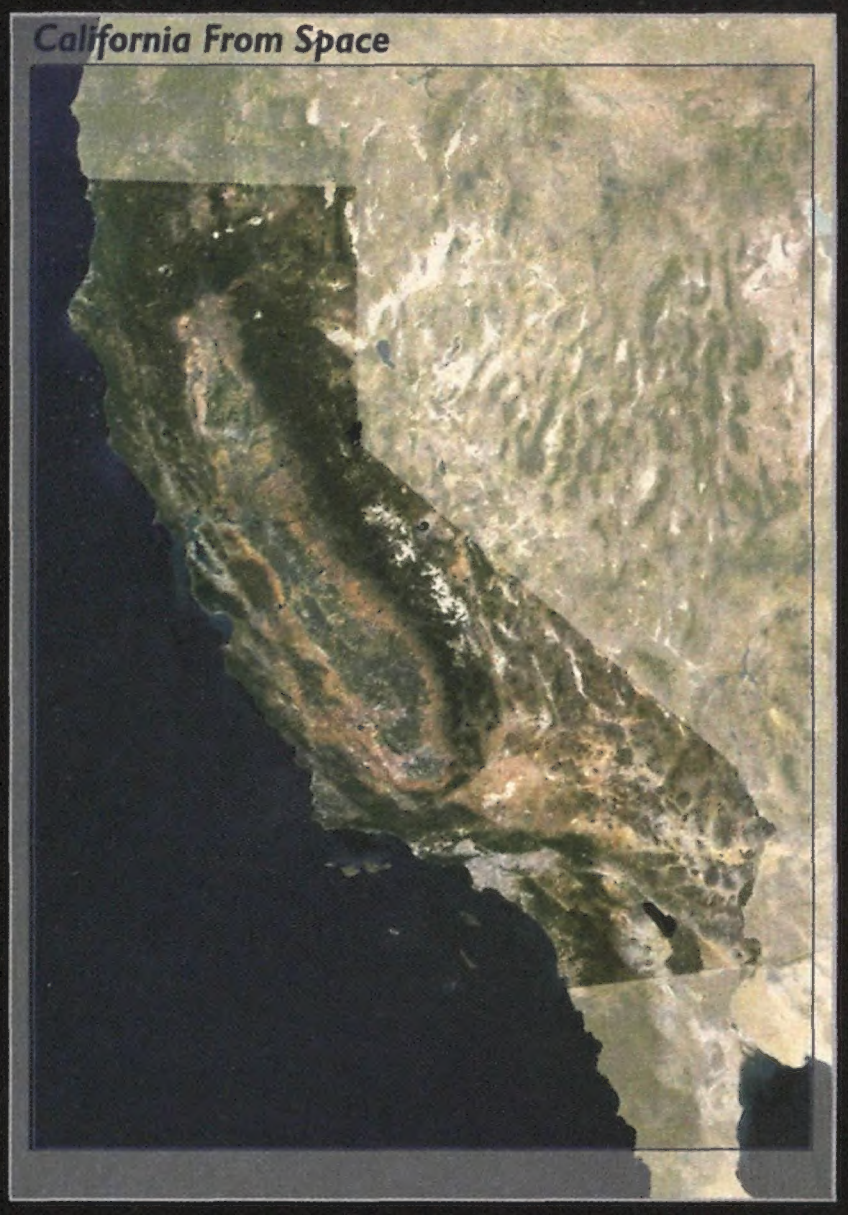

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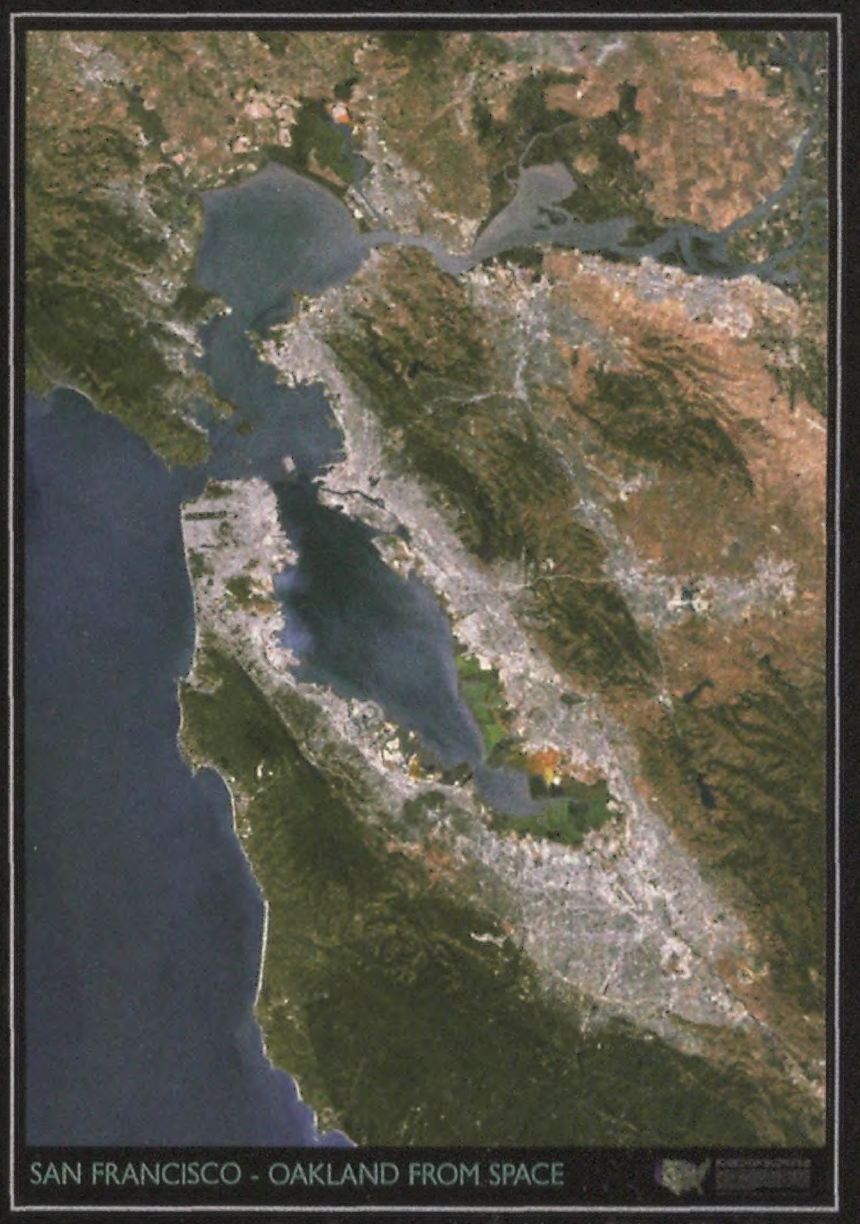

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Smithsonian

April/May 2000
Volume 15 • Number 1

BONUS POSTER

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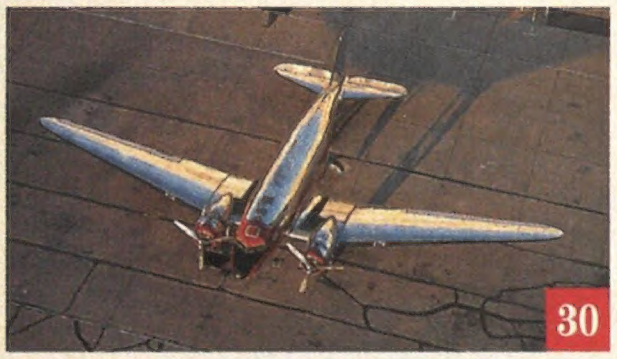
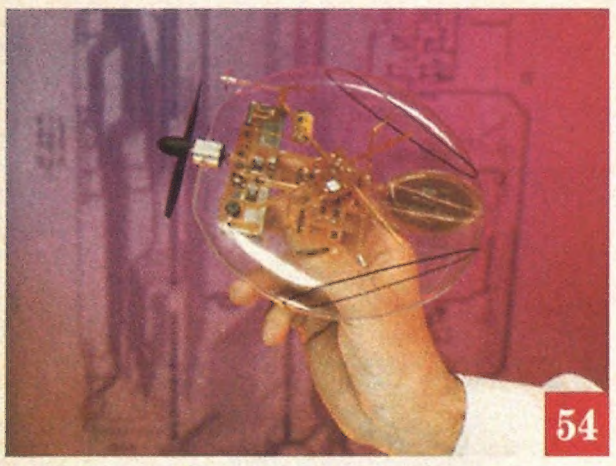
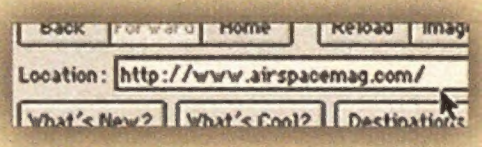




Cover:
Not just another pretty face: The DC-3 in Eric Long's portrait hangs in the National Air and Space Museum, but a hundred others are still working stiffs.

DEPARTMENTS



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First Impressions

The National Air and Space Museum is a tribute to everything that has made this country great: It reflects ingenuity, innovation, persistence, courage, success, and disappointment—often all in the same artifact. The exhibits are designed to be accessible, clear, and concise in order to impart knowledge to large groups of visitors with varied backgrounds and interests (and often limited time) so that people can fully enjoy the experience. For the serious student, there are reams of information in our library and archives, much of it digitized, complemented by a staff of experts available to assist researchers. The expertise that resides here can overwhelm even the most accomplished of ready room storytellers. Now I am privileged to be a part of it all and a bit in awe of my surroundings.

Let me introduce myself: I'm Jack Dailey, the new director of this national treasure. I arrived here after seven years at NASA and, prior to that, 36 years as a Marine and Naval aviator. My dad was a Marine aviator who had his introduction to combat in Nicaragua and finished up in Korea; I represented the family in Vietnam. My life and my principal interests have always revolved around aircraft and, more recently, spacecraft.

Even though I have been associated with the Museum for several years as a member of the advisory board, there are some important aspects of its operation that I did not understand, the most important of which is that we must raise private funds for essentially everything we do. Appropriated funds cover salaries for federal employees and some maintenance, but the exhibits and other programs are primarily funded from private sources. The generosity of the American public and our international partners is what really makes this place tick. I am very impressed with the consistency of the support provided by organizations and individuals.

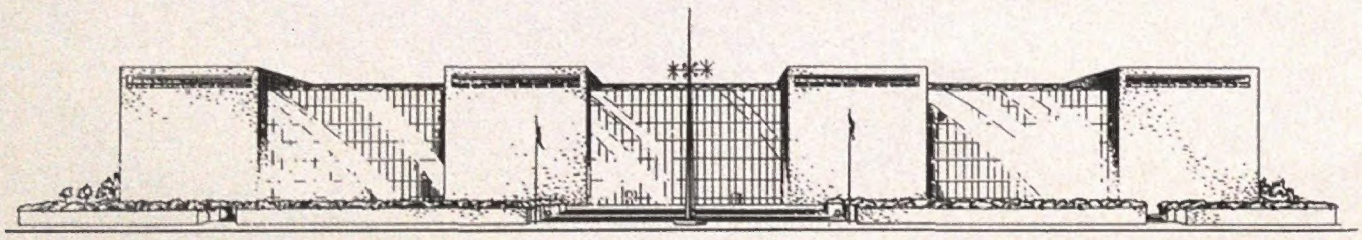
Nowhere is this more evident than in the campaign to fund the Dulles Center. We are on course for a December 2003 opening to support the centennial celebration of the Wright brothers' flight. Although we have a long way to go before we reach our funding goal, we are making steady progress and are optimistic that we'll get there.

One of the major benefits of the new facility will be the significantly increased ability to support educational activities. We will have classroom and laboratory facilities that are not available in the museum on the Mall and that will enable us to host classroom-size groups of visitors more effectively. We will be able to provide support to teachers in course development and provide an ideal setting for stimulating interest in math and science.

In addition, Fairfax County in northern Virginia has funded a new high school that will feature an aviation curriculum. Its location directly across from the Dulles facility will provide us with an opportunity to work closely with the students. Of course, these same opportunities will be available to students from across the nation who want to take advantage of them.

I see a bright future for us and am looking forward to the challenges that our team faces in completing the new facility and keeping our museum on the Mall the most popular in the world. And as a lifelong aviator and aerospace enthusiast, I think I have found Valhalla.

—John Dailey is the director of the National Air and Space Museum.



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LETTERS

Not-So-Happy Trails

"Choked up" is not a reaction I normally get when reading *Air & Space*. But that is how I felt after reading Stephan Wilkinson's "Addio, Falco" (Above & Beyond, Feb./Mar. 2000). The author did a great job of relating the facts and the emotions of something that all of us will have to face someday—the decision to stop flying.

—Robert B. Martin
Denver, Colorado

"Addio, Falco" was simply but powerfully written—and very demoralizing. The lesson is to know when to hang it up, but with someone such as Mr. Wilkinson, who is I suspect quite a ways yet from dotage, I think something else was going on. Alternatives are available for those who want to fly but who realize the need for additional training. Perhaps some dual instruction in an aircraft less exotic was considered, but somehow lost its appeal. Like anything else we strive to do well, or competently, we must expend the time and effort. Flight has given us so much, and how sad a farewell from one of its more visible practitioners.

—Jeff Pardo
Rockville, Maryland

Not So Fast

I was flattered to see that my photograph of the Soviet Mi-24 Hind inspired an artist ("Carbon Copy," Letters, Feb./Mar. 2000). I think it important to remind magazine readers, however, that photographs are copyrighted works in themselves and may be copied for personal enjoyment only—as was the intent in this case—and not for sale. I fear that publishing the artist's letter and copy may convey the impression that photographs are not the property of the photographer who makes them. They are, and they are protected by law. Unfortunately, the magazine compounded this miscommunication by not attributing the photograph to me in the box that described the artist's copy.

—Chad Slattery
West Los Angeles, California

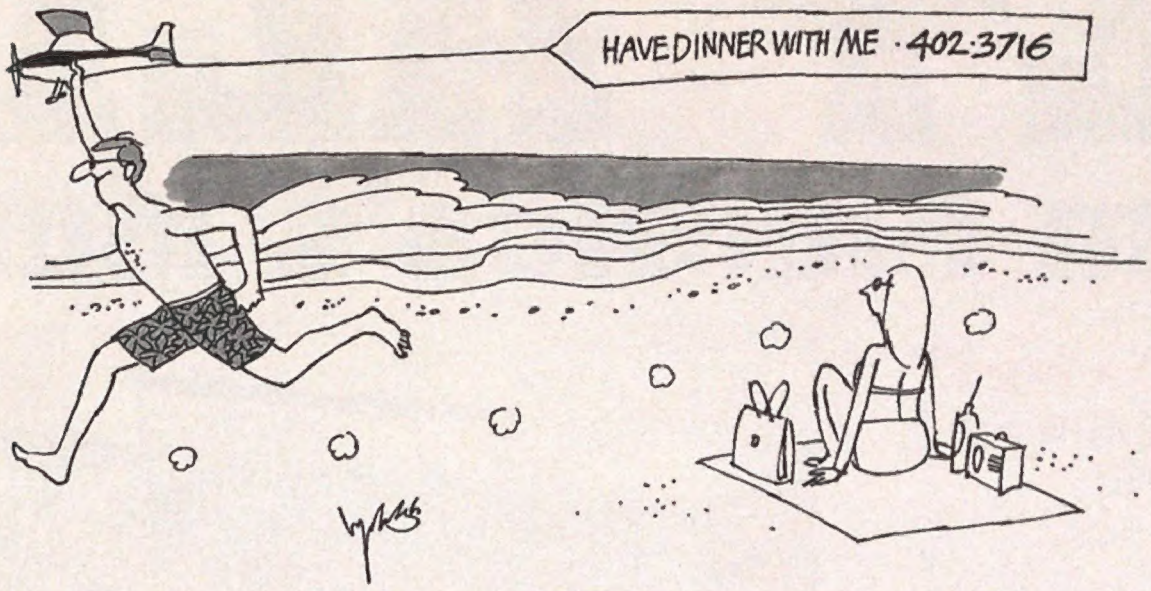
Memo to Washington: Get More Mirrors

The way I read Senator Tom Harkin's essay (Commentary, Feb./Mar. 2000) is that he is criticizing NASA for the direction it is taking in a national space program. NASA is a government agency, I believe. Leadership starts in Washington, D.C., with the president and then Congress. Things have changed, though, since the era of Sputnik and President Kennedy's speech: Gone are the days of high-stakes, high-dollar outlays to put a person on the moon, and gone are the times of Star Wars and 600-ship navies. Today Congress is cutting spending to or not even funding large military and NASA programs. Instead they are trying to do more with less. The low morale and high turnover in the military could also be traced to this more-with-less philosophy. Harkin and other senators need to look into the mirror and ask themselves, "Are we prepared to lead and fund programs that will put people back on the moon and/or other planets?"

—Frank Glover Jr.
Mt. Pleasant, Texas

I read Senator Harkin's essay with amazement. Were it not for Congressional

Air rage



budget cuts and idiots like William Proxmire and Walter Mondale, NASA would have flown Apollo 20, established a permanent space station, and perhaps colonized both the moon and Mars by now. How much would our society have gained by the technology the space program would have generated through such ambitious programs? Stop blaming NASA, senator, and take a long look in the mirror when looking for the reason NASA is where it is.

—David Robinson
Atlanta, Georgia

Keeping the Blues at Bay

I understand why the Blue Angels cannot bend their airshow rules ("Got the Blues?," Feb./Mar. 2000). All it takes is to see one film clip of an airshow routine gone bad to see that spectator safety—and the safety of the pilots themselves—is of prime importance. I have experienced flying in a diamond formation, including a loop, in propeller airplanes and the extreme concentration and superb airmanship of the pilots has to be seen to be believed. To know that the Blue Angels fly so fast and so close is to know that one extremely small error in concentration could spell total disaster. Hats off to the Blue Angels for their unyielding airshow rules, which enable us to watch their routines in relaxation, comfort, and safety.

—Richard Reuter
via e-mail

Angels Among Us

Thanks to Tom LeCompte for his informative and uplifting article about what may be one of aviation's best kept secrets ("Center, This Is Compassion Seven-One-Golf," Feb./Mar. 2000). In an era when community airports across the U.S. are being jeopardized by developers and short-sighted civic administrators, it is good to be reminded that, far from being just an expensive hobby for weekend enthusiasts, private aviation takes care of a lot of business.

It also seems that one of the great merits of using personal aircraft for public-benefit activities is the sense of community that it inspires. When we participate as volunteer pilots, we realize we could just as easily be the ones in the grip of debilitating disease. In turn, these people, besides getting direct help, also come to know that others, without a financial interest, care about them and their families as fellow human beings. I find it gratifying to see that private aircraft—so often the token of wealth and privilege—are being used to mend a great gap in the health care net by making resources that already exist accessible to more people. I believe that in so doing these compassionate individuals are also helping to mend the soul of America.

—Bill Worden
Venice, California

Phantom Bombers

As acting chief of the Air Force's reconnaissance branch during the early days of the Soviet and U.S. military buildup, I served as a photo interpreter for many of the reconnaissance missions ("Alone and Unarmed," Feb./Mar. 2000). The total number of bombers estimated turned out to be far greater than the number actually counted. This disparity, it was later discovered, resulted from Soviet subterfuge. The Soviets always showed their latest military hardware in the Moscow parades held in May and October. These parades were accompanied by flyovers of the latest combat aircraft. The first heavy jet bombers were seen in 1953, and while limited in actual numbers, the Soviets reflew the aircraft over the parade area several times, making sure that the tail number of each airplane was changed for

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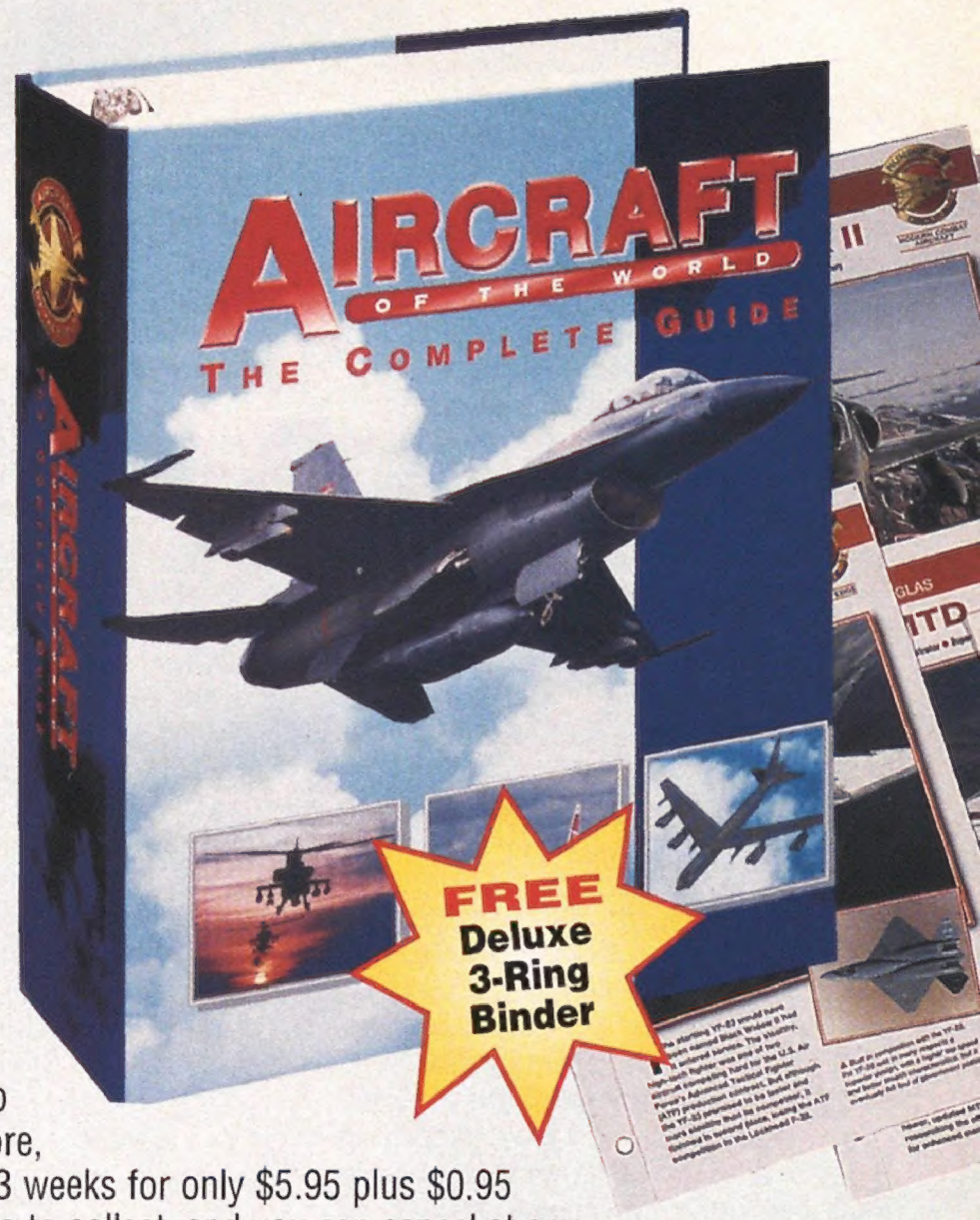

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each pass. This caused an overestimation of the strength of the strategic bomber force, and led to the rapid buildup on both sides as each tried to close the gap.

—Col. Frederick R. Sager
U.S. Air Force (ret.)
Riverside, California

Taken for a Ride?

Your article was wonderful and long overdue. There are a lot of people who would love to be introduced to sport or fun flying but don't know how to go about it or where to look. Unfortunately, in your directory you jumped from Texas right to Virginia and left out Vermont! At the Warren-Sugarbush Airport in the heart of the Green Mountains, we give glider rides, we take up passengers two at a time in our beautiful Schwiezer 232, we host Summer Youth Camps and soaring competitions, and we serve as the base airport for powered flight and aerobatic instruction. Stowe Soaring is 40 or so miles north of us and also gives scenic rides and instruction in gliders and powered aircraft, as do Post Mills and Springfield airports. Middlebury, Bennington, Montpelier, Burlington, and Swanton all have excellent flight schools and give scenic rides to those who want to see the beauty of New England from the air in craft as diverse as hot-air balloons and Russian Yaks.

—Eric M. Hanson
Warren-Sugarbush Airport
Warren, Vermont

On the contents page, a photograph shows a sign advertising biplane rides, yet the article ("Airplane Rides," Feb./Mar. 2000) makes no mention of the sign's owner, Vintage Aircraft Company in Sonoma, California, one of the most professional ride operations in one of the most beautiful parts of the country.

Chris Prevost, owner of Vintage Aircraft Company, has been in operation for over 15 years. He has personally rebuilt each of the three PT-17 Stearman biplanes he flies. The author left a lot of good operators out of his article, and included a few marginal ones.

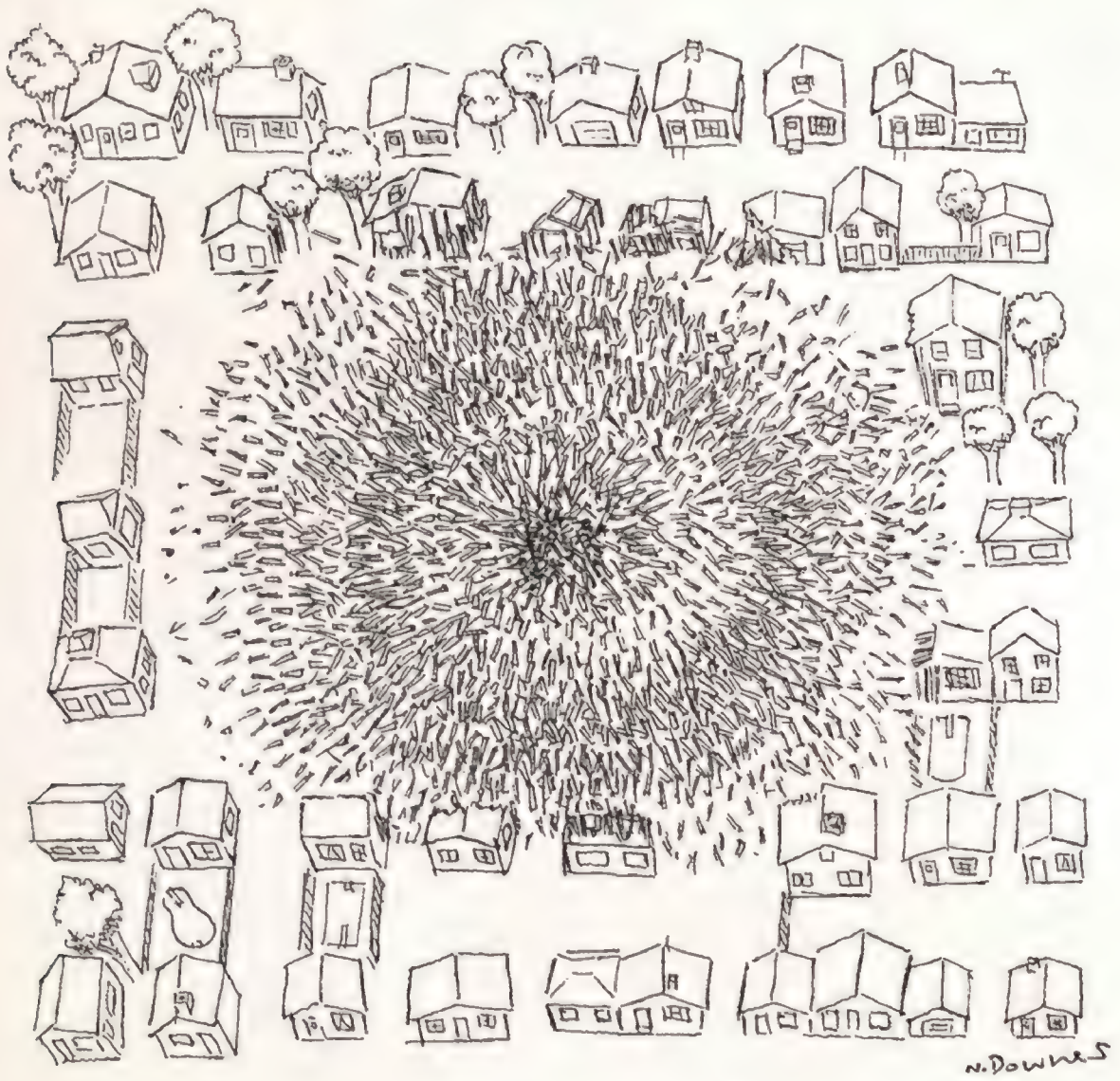
—Robert Campbell
San Francisco, California

Editors' reply: Regrettably, we didn't have room to include every group that offers rides to the public. We repeat the author's advice: Eager aviators should consult their local airports to discover where they can go to try their wings.

If Something Can Go Wrong ...

Your mention of the passing of John P. Stapp ("Departure," Soundings, Feb./Mar. 2000) left out his most enduring contribution to aerospace engineering: his role in the formulation of Murphy's Law. His assistant, Captain Edward Murphy Jr., designed the rocket sled sensor harness Stapp was to strap on. There were exactly two ways each sensor could be installed—and Murphy did each one the wrong way. After enduring a 600-plus-mph ride and a brutal deceleration, the only records of the test were Stapp's swollen eyes and disheveled appearance. Murphy soon coined his ubiquitous maxim based on this event: "If there are two or more ways to do something, and one of these could result in a catastrophe, then someone will do it that way."

—Mark M. Williams
Lockheed Martin Missiles and Space
Woodside, California



Aerial view of the epicenter of a conniption fit.

Corrections

Feb./Mar. 2000 "Got the Blues?": Dozens of readers pointed out that (1) Little Rock Air Force Base is in Arkansas, not, as the caption on page 36 states, Alabama, and (2) the body of water where Seattle's annual Seafair hydroplane race and airshow is conducted is Lake Washington, not Lake George.

"Award Night," In the Museum: The 1999 NASM Trophy for a current achievement was awarded to the Breitling Orbiter 3 team. Alan Noble represented the team—along with Brian Jones and Bertrand Piccard—and was not the award's sole recipient.

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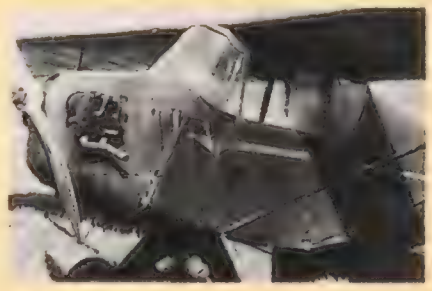
A $200 Taxi Ride

While reading "Antiques Airshow" (Collections, Feb./Mar. 2000), I noticed a reference to a Porterfield CP-40 in the Airpower Museum's collection. As a 15-year-old in 1945, I owned that very aircraft with my buddy, Mike Corba.

We had both been aviation enthusiasts from our very early years, building models and visiting local airports on the weekends. It was during one of these visits that we learned of a 40-horsepower 1936 Porterfield Zephyr that was for sale for only $200. Although flyable, the airplane was in need of much repair, including complete replacement of the fabric covering. Somehow we scraped up enough to buy the airplane from its owner. A few days later, he delivered it, but to a neighbor's hayfield instead of our own. This was not a major problem, as we simply pushed the old bird down Route 95—there was little automobile traffic in those days—and into our hayfield.



The old Porterfield in 1945 (top) and, reunited with Collier, in 1995 (above).

Although only 15 years old, I had already taken some formal flying lessons and had four hours in my logbook. Using this vast experience, Mike and I found great delight in firing up the old bird and taxiing her wildly around in the hayfield. Passing drivers, thinking we were about to take off, would pull to the side of the road. When it became evident that we were not, they drove off.

After a week or so of this, we decided that the road offered far greater freedom. Aware of how large our aircraft's wingspan was in relation to the two-lane highway, we decided to forgo flying and remove the wings. This would be required for recovering anyway, we reasoned. With the wings safely stored on some hay in the barn, it was off to the highway. Without the hayfield's restrictions, we could really get her moving on the long stretch of highway. When an automobile came by, the driver, seeing a wingless airplane approaching, would pull off to the side of the highway. As we raced by the bewildered motorist, we would wave and laugh heartily. Coasting to a stop—the Porterfield had no brakes—one of us would get out, swing the airplane around 180 degrees, and jump back in, and we'd be off again.

When Dad saw what we were doing, he immediately put a stop to the nonsense. We pushed the fuselage into an area where it would be safe from our farm animals. By now we had come to the realization that the task of rebuilding the aircraft was not only beyond our capabilities but beyond our financial means as well. We put the word out at the Mansfield, Ohio airport that the Porterfield was for sale.

Many years later I tracked down the Porterfield, and learned that it had been restored by one of its later owners and donated by the most recent—Porterfield Club president Chuck Lebrecht—to the Airpower Museum. About five years ago, when returning from the Experimental Aircraft Association's annual bash in Oshkosh, my wife and I went out of our way to visit my old friend in Ottumwa.

—Myron W. Collier
Cyclops Professional Flight Services
McMurray, Pennsylvania

The Seminoles' Corvette With Wings

James Billie leads the Seminole Tribe of Florida, but the six-term chief protests he's "not what we call a 'brave.' I've never stuck my rear end into an experimental [airplane]." That's why he waited five years to ride in the first airplane built by the tribe's own airplane factory.

Billie finally took a spin over Fort Pierce, Florida, last January 15, the chilly, windy day a Federal Aviation Administration official handed the first type certificate of the 21st century to Micco Aircraft Company for its MAC-145A. "Now I'm ready to learn how to fly this thing," said the 55-year-old chairman, an accomplished private pilot who traded alligator wrestling for flying lessons when he was 28. (Two weeks after his flight, in Billie's first bout with a gator in 10 years, the chief lost his right ring finger to a seven-foot alligator in an impromptu wrestling match staged for the tourists at Billie Swamp Safari in the Everglades.)

The single-engine, two-seat tail-dragger will be manufactured and sold as the Micco SP20. It's a revival of a 1948 design by general aviation pioneer Al Meyers that targeted pilots who had returned from World War II. Only 20 Meyers 145s were built, but they were well respected for their ruggedness.

Billie liked the Meyers' slick profile and jumped at the chance to buy the type certificate from its owner, who had purchased it in 1984 to start production but could not find adequate financing. Micco Aircraft was formed as New Meyers Aircraft in Wichita, Kansas, in 1994. It moved to Florida in 1996. "I think it's important that our tribe continue to diversify its resources," Billie said. The Seminoles are nationally known for their entrepreneurship. They pioneered the multi-billion-dollar Native American gaming industry in 1979 and were the first tribe to own and operate a hotel, as well as the first tribe to operate an Internet marketplace.

Flanked by a flight test model and a demonstrator, the first production Micco SP20—with Billie in the copilot's seat and a four-color feather logo on its tail—made a low pass by the manufacturing hangar at St. Lucie County International Airport. All three airplanes tipped port wings to a cheering, whistling crowd of 400 employees, industry executives, tribal leaders, and other dignitaries.

Billie struck a proud post-flight pose with his elder son—the company's seven-year-old namesake—on the wing before handing the keys to what he called his "Corvette with wings" to John Vandervort of SoCal Aviation in Santa Monica, California, one of six distributors nationwide. (Micco is derived from the Seminole word for "leader" or "superior one.") "Two hundred seventy days is all it takes to have a baby," Billie said. "This took me five years, but it was the same pains."

The Micco SP20 incorporates components from two other Meyers designs—the vertical stabilizer and rudder from the 200 model and the wings and flaps from the Interceptor 400 turbine model. It cruises at 160 mph and has a sliding canopy, retractable gear, and a 200-horsepower engine. The basic SP20 sells for $147,500. A 260-horsepower model for aerobatics, the SP26, is in the process of being certificated, and a four-seat version of the SP20 is in the works.

—Beth Dickey

After his first flight in the tribe's brand-new airplane, James Billie and his son Micco, for whom it was named (the Seminole word for "leader"), reflect on its potential.

ERIC HASERT/FORT PIERCE TRIBUNE

SALINGER IGOR

Yugoslav Aeronautical Museum director Cedomir Janjic (fifth from right) studies the remains of a BGM-109 Tomahawk cruise missile with visiting dignitaries.

Spoils of War

When Operation Allied Force ended last June, the Yugoslav Aeronautical Museum in Belgrade, Serbia, began adding some very interesting items to its collection—like the remains of a stealth fighter, cruise missiles, unexploded and exploded ordnance, and the latest in unmanned aerial vehicles.

"Aviation archaeology has been an important segment of our activities since the museum's founding," says general manager Cedomir Janjic. "During the war in Croatia and Bosnia, YAM teams went to crash sites to recover remains of downed aircraft—Yugoslav, Croatian, British, American, Ukrainian, French. When NATO aggression started, we continued to do the same—however, this time it was much nearer." Salvage operations often took place under air raid alert—"We wanted to be at the right place when something happened," says Janjic. And shortly after the end of the campaign, Belgrade Parking Services showed up at the museum with a load of Tomahawk missile remains on its tow truck. "During the aggression, their task on behalf of the city was to clear as much as possible of the remains," Janjic says. "When it was all over, the city donated it to us."

A new collection, "Exhibits That Fell from the Sky," opened last December, during Air Force Day celebrations. "Ordinary people asked 'What were we attacked with? What are these smart weapons used against us?' and we did our best in order to answer these questions" by exhibiting them to the public, Janjic says. Currently on display are parts of two aircraft acknowledged by NATO to have been lost over Yugoslavia (both pilots were rescued): an F-117A downed near Budjanovci on March 28, and an F-16C shot down on May 2 near Sabac in western Serbia. What remains of the F-117 is the canopy, ACES II ejection seat, pilot's helmet, and Forward/Down Looking Infrared system exterior units. From the F-16 there is the vertical tail, cannon, ejection seat, right-side main landing gear, and fuselage parts.

Hanging from the ceiling is a Predator unmanned aerial vehicle—minus the tail identification, which allegedly was cut off and spirited away by a Serbian TV reporter at the crash site. Also displayed is the wreckage of a German CL289 UAV. In addition, the museum received spent ordnance, including the remains of a BGM-109 Tomahawk cruise missile downed on the first night of attacks near the Ladjevci air base, and an AGM-84 Stand-off Land Attack Missile marked with graffiti: "Here's your cease fire, baby."

Presently only some five percent of the museum is dedicated to the Allied Force exhibit. YAM has an extensive collection of more than 200 aircraft, including a Nieuport, Spitfire, Me 109, Yak-3, Ju 52, T-33, F-84, and MiG-21—and not nearly enough space.

And there's more to come. "There are lots of exhibits-to-be that are spread all over the country," Janjic says. At the moment he was preparing for a trip near Kraljevo in order to recover what was described as "a 1,000-kilogram unexploded bomb."

—Salinger Igor

FLASH!

From a press release on Boom Beam, a xenon landing light system from the aircraft modification company LoPresti Speed Merchants:

"The Boom Beam has demonstrated that it is VERY fast (our kind of mod). So fast, in fact, that we have been unable to measure its speed. We've come close to catching the Boom Beam with some of our highly modified airplanes, but when we get close to the leading edge of the high speed light, the clocks in the plane start slowing down and the pilots feel that they are getting younger. If you have any suggestions for measuring the Boom Beam's speed, please call us...if your name is Einstein, e-mail us." Contact LoPresti at (561) 562-4757, Info@FlyFast-LoPresti.com

UPDATE

Making It Legal

Up-and-coming pilot Jamail Larkins, who had to decamp to Canada to make his first solo flight ("How to Solo at 14," Soundings, Oct./Nov. 1998), made his U.S. solo last January in a Cirrus SR20 in Augusta, Georgia, the day after his 16th birthday. Having logged more than 260 hours in 34 different types of aircraft while waiting to reach the legal age to solo in the United States, Larkins said upon deplaning, "I've been waiting a long time to do this." Larkins was recently named the national spokesman for the Experimental Aircraft Association Vision of Eagles program, which encourages youngsters to learn to fly.

Worth a Second Look

When a V-1 cruise missile chased my mother out of the bathtub in 1944, it was its unmistakable noise that warned her to grab my brother and a robe and take cover. The V-1 sounded like a motorbike due to its pulse jet engine, which, like a car engine, used a spark plug to ignite the air-fuel mixture intermittently.

Noisy, inefficient, and rough-running, the pulse jet fell out of favor when World War II ended. Now a new generation of pulse detonation engines is attracting interest. NASA has selected the PDE as one of its Revolutionary Concept projects and hopes to fly one on an SR-71 research

aircraft in 2002, while Boeing and Pratt & Whitney have joined Adroit Systems—a small company that has been working on PDEs since 1992—to explore the technology.

Like the V-1's pulse jet, the PDE is a combustion chamber with a valve at one end—which opens to admit air and fuel and closes to contain the expanding gas after ignition—and a nozzle at the other. The difference in today's PDE is that the air-fuel mixture does not burn but detonates. A detonation wave moving at 10,000 feet per second completes the combustion process before the gas can expand, efficiently generating high temperatures and pressures.

Unlike a conventional jet engine, the PDE needs no turbine-driven compressor to pump the air to high pressure before the fuel is injected. This eliminates the engine's hottest, most complex, and most expensive hardware. Moreover, in a conventional jet engine, speed of operation is limited because the compressor temperatures rise in flight. No turbine engine is known to have run much faster than Mach 4 because at that speed the compressor temperature is at the limit that materials can withstand. The PDE, like a ramjet, has no such limitation, but—unlike a simple ramjet—it will produce thrust when it is not moving.

The high-speed capability of PDEs, coupled with reports of "pulsing" sounds emanating from the U.S. Air Force flight test center near Groom Lake, Nevada, has caused some people to make a connection between secret aircraft with PDEs and intermittent contrails—the so-called "doughnuts on a rope" reported by desert skywatchers. But the numbers don't add up. In the PDEs that Adroit has ground tested, each combustion chamber runs at about 40 Hertz (cycles per second), so the company plans to use multiple combustion chambers to reduce vibration (similarly, in a V-8 engine compared to a four-cylinder model, the power pulses are more numerous but weaker). A four-chamber engine would run at 160 Hertz. Even if the aircraft were flying at a mile per second, the pulses in the exhaust stream would be 30 feet apart and indistinguishable to an eyewitness almost 20 miles below.

NASA has teamed with Huntsville, Alabama's ERC Inc. to test a pulse detonation rocket engine that promises high performance without the high-pressure turbopumps needed by today's rockets. Missile and rocket designers are taking a closer interest in PDEs than producers of manned aircraft are, but Adroit believes that PDE principles could be combined with turbine technology in the form of quiet, efficient hybrid engines for commercial aircraft.

—Bill Sweetman

The Rage in Maine Falls Mainly From the Planes

Air rage—that relatively recent phenomenon of a passenger going ballistic aboard airliners—is all the rage in Maine, at least in Bangor. In little over a month last summer, three airliners diverted to this remote airfield to offload their drunk and disorderly. "Very quickly we got a lot of attention," says Jeff Russell, marketing manager for Bangor International Airport. "The incidents showcased our ability to turn a plane around in nothing flat."

Since then, the airport has become the unscheduled stop of choice for flights carrying passengers turned violent—in no small part due to Russell's marketing campaign (Bangor handles about a dozen such stops a year). Consider the advantages the airport offers: It's open 24 hours a day, 365 days a year.

UPDATE

Models Land at Museum

The 24 dioramas chronicling aviation history in 1/32 scale that model maker Bill Topping built in the 1970s and 1980s ("The Model Man," Oct./Nov. 1996) were recently purchased by the Santa Maria Museum of Flight in California, where they are displayed under clear plastic covers. "Our ex-president, Katherine Hulme, knew Jack Rowe, who was acting as an agent to Mrs. Topping in the sale of the collection," says museum president K.R. Weber. "Mr. Rowe was kind enough to inquire if we had an interest in them. It certainly didn't take long to say yes."

At a moment's notice Bangor International can have FBI and Customs agents on board to remove the offender and book him at a federal courthouse just down the road (disrupting a flight comes under federal jurisdiction). Passengers can calm their jangled nerves in the terminal with liquor purchased in the hastily opened duty-free shop while the authorities take witnesses' depositions. The crew can file fresh flight plans while Bangor crews restock and refuel the aircraft—and everyone can be back in the air in under an hour, according to Russell.

"What gives us

DAVID CLARK

CHAD SLATTERY

SR-71 old hands Bob Gilliland (left) and Jim Eastham helped celebrate the 35th anniversary of the Blackbird's first flight.

a significant advantage is [that] the time it takes for us to turn a plane around is the time it takes a plane to taxi to the gate at most airports," he says.

Before it became Bangor International, the airfield served on the cold war's front lines as a Strategic Air Command base, hence its 11,439-foot runway, one of the longest in the world. Bought by the city in 1968 for one dollar, officials hoped to turn the field into the gateway for northern Maine, with its fishing, hunting, and outdoor fun for tourists. But at the moment people are flying to Bangor less for tourism than for unexpected diversions such as maintenance and weather problems and, yes, air rage.

—Phil Scott

UPDATE

The New, Improved F/A-18

The U.S. Navy has pronounced the F/A-18E/F Super Hornet "operationally effective and suitable," which sounds like damning with faint praise but is in fact the highest rating possible from the Navy's Operational and Test Evaluation Force ("Final Exams," Soundings, June/July 1999). Topping that, the National Aeronautic Association announced that it is awarding the aircraft the Collier Trophy for the top aeronautical achievement in 1999.

Habu at 35

For "ooh, aah" aviation fans it was a 10 on everyone's scale—even when the California high desert wind kicked up about noon, like some stealthy spirit from the SR-71's glory days, scattering table-top displays and handouts. Thirty-five years ago on this mild December day, the legendary spyplane made its first flight.

Hundreds of tourists, pilots, and kids celebrated that anniversary at Blackbird Airpark, where SR-71 tail number 973 and a predecessor, A-12 tail number 924, sit just outside Edwards Air Force Base. The Blackbird (or "Habu," which the Okinawans named it, after a deadly local pit viper) was dreamed up, engineered, and assembled at the nearby Lockheed Skunk Works.

For Bob Gilliland, who made that secretive first flight on December 22, 1964, memories surfaced as he signed autographs and answered questions. "[Designer] Kelly Johnson raised the question, 'Should we raise the landing gear [to enable supersonic flight]?' He asked me how I felt about it and I said I had great confidence in the ejection system, so I don't really care," Gilliland said. "A couple of days later he said, 'Let's do it and we'll knock off supersonic at the same time.' I do recall we had 383 non-flight-critical 'open' items—things that should have worked but didn't."

Also on hand was Jim Eastham, who made the first flight of the YF-12A long-range interceptor version in August 1963. Eastham, who takes great pride in being an engineer and in having flown all the Century series of fighters, this day faced no greater danger than writer's cramp from signing autographs.

No one enjoyed the day's celebration more than Bill Windsor, a retired Los Angeles TV reporter. As a newsman from a small TV station near Beale Air Force Base in Northern California, he first saw the unique craft at a media day in 1966. With a strict prohibition against filming the airplane, reporters were allowed to watch it land, then were given a sanitized "handout" film. This anniversary day, Windsor, having earned his pilot's license since then, realized a dream: to sit in a Blackbird cockpit. "I was so struck that it was so roomy," said Windsor, who, as did dozens of others, made a $15 contribution to the museum for a photo of themselves *in situ*.

Former mission pilot and retired Air Force Colonel Jim Wilson couldn't get to the party, but he remembers the airplane with pride. Once the squadron operations officer for the aircraft's 9th Strategic Reconnaissance Wing at Beale, Wilson recalls, "The SR-71 contributed in a major way to winning the cold war, even though it was never used for its ultimate all-out-war reconnaissance mission." Reason enough to party.

—Bob McCafferty

NASA

The world's largest parachute unfurled over Yuma, Arizona, last January, lowering a test pallet standing in for the X-38 Crew Return Vehicle ("Lifeboat," Aug./Sept. 1998). Dropped from a C-130 over the U.S. Army's Yuma Proving Ground, the 143-foot-span parafoil, with a surface area of 7,500 square feet, was deployed by an extraction chute and stabilized by a drogue chute, which slowed the landing speed of the 18,000-pound pallet to 8 mph. Our condolences to the crew that had to retrieve the monster parafoil and pack the whole thing up again.

Beautiful Obsession

It was 1971 when an unknown pilot in an unknown airplane brashly signed up for the Unlimited class of the U.S. National Aerobatic Championships. There, among the barrel-chested Pitts Specials, the airplane *du jour* for U.S. aerobatic competition, Leo Loudenslager sliced up the sky in a little razor of a homebuilt monoplane called the Stephens Akro. He placed a mere 10th, but he made a lot of people sit up and take notice. Four years later, the new guy was back with the Laser 200 (right), a highly modified and even lighter version of the Akro that won the championships and changed the course of competitive aircraft design. Loudenslager won another six championships—an unprecedented string of victories—plus a World Champion title in 1980, and by then, competitors were buying lightweight mid-wing monoplanes like hotcakes. In the mid-1980s Loudenslager and the Laser, named *Beautiful Obsession*, joined the flying circus, bringing his finely honed flying to the public and setting a high-water mark for airshow performances with maneuvers like a vertical outside snap roll, which pulls a whopping 8 Gs.

A few years ago, longtime performer Wayne Handley, who flies a mid-wing monoplane, got the rare chance to fly Loudenslager's Laser. "Curiosity motivated him to suggest we swap airplanes," says Handley. "He'd been eyeing my tumbling maneuvers in the Raven." When Handley climbed in the Laser cockpit, he discovered one of the qualities that gave Loudenslager the leading edge. "He was obsessed with weight," he says. "He had cut bolts and screws to be absolutely flush. Anything that could have holes drilled in it did. Even the seat belts were trimmed to a quarter-inch of the rollers." Once airborne, Handley saw the benefit. "We did stalls together, and as we decelerated, Leo in the Raven stalled and fell off. I'm nice and comfortable in the Laser for another 10 knots. And I thought, Aha! This is the importance of weight in an aerobatic airplane."

BUDD DAVISSON

ERIC LONG

All the while, a new airplane, even lighter and nimbler than the anorexic Laser, took shape in the back of Loudenslager's mind. For some 10 years he planned it, drew it, refined it, shaved off an ounce here and there. In the mid-1990s, the Loudenslager Shark came together under wraps—a civilian "black airplane"—in a hangar in Guthrie, Oklahoma, built by Bill Zivco to Loudenslager and Zivco specs. "He wouldn't tell me much about the new airplane," says Handley. "He once said, 'It has some cutesy little things about it.' " Rumors about the mystery ship flew through the airshow circuit: Loudenslager was going to turn the aerobatic realm on its tail again.

In July 1997 a far greater blow shook the airshow community. Loudenslager was in a motorcycle accident, and he died from complications. Last October, Loudenslager's daughter, Carolyn, loaded the Laser on a trailer in Tennessee and drove it to the National Air and Space Museum's Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland (left). The airplane will eventually hang in a gallery with a Pitts Special. "I wanted the airplane because of its pilot and its design," says aeronautics curator Dorothy Cochrane. "People were starting to do more tumbling and all, but he really set the challenge and the standard. Clint McHenry, a multi-time champ and competition judge, said he had only seen two perfect aerobatic routines, and Loudenslager flew both of them. His airplane knocked biplanes out of the Unlimited category for good, as its basic design led to today's dominant Extra line

On April 20 at 7:30 p.m., pilots Brent Hisey (right) and Bob Avery will speak at the National Air and Space Museum's Langley Theater. They will share stories about *Miss America*, a P-51 Mustang that began its racing career in 1969 and won the Gold Unlimited at the 1994 National Championship Air Races in Reno, Nevada. Hisey, *Miss America*'s owner and race pilot, and Avery, its business manager, will also give a history of the world's fastest motor sport. Admission is free.

and other powerful and strong monoplanes."

Loudenslager never got to fly the Shark, but his admirers will have a chance to see the airplane, which will hang at the Experimental Aircraft Association's museum in Oshkosh, Wisconsin. "I wouldn't have built this for anyone else," says Zivco, referring to the tremendous research and development effort of creating an exotic new aircraft. "He was a special person." Constructed of lightweight carbon fiber, titanium, and magnesium and featuring a pivoting horizontal stabilizer that would have facilitated a greater array of tumbling maneuvers, Loudenslager's last design proves that when it comes to aerobatic airplanes, less is truly more.

—Patricia Trenner

Machinist-in-Residence

George Vencelov (right) is a sculptor. That may be a slight exaggeration, but as the resident machinist at the Museum's Garber restoration facility in Suitland, Maryland, Vencelov's job is to make aircraft parts out of solid blocks of aluminum, steel, brass, and plastic—whatever the job requires. The work is often tedious, but the results are nothing short of superb.

Vencelov is currently fabricating a part for the Aichi Seiran, a Japanese aircraft designed for the purpose of bombing the Panama Canal during World War II, a mission that was never carried out. The Museum has the last surviving example of the Seiran, which has just finished undergoing a 10-year restoration. Since the Seiran's drift sight was missing, Vencelov was assigned to replicate the three-foot-long instrument.

Drift sights were used to measure the effects of wind on an aircraft in flight, enabling air crews to make course corrections en route. Drift sights were especially important to airplanes operating over water. Without them, a pilot could arrive over land without knowing exactly where he was, or which way he needed to fly to reach his target. In the case of the Seiran, the aircraft would have been launched from a submarine hundreds of miles from its target, and since the Panama Canal was heavily defended, staying on course was vital in order to preserve an element of surprise.

In the 12 years Vencelov has been at NASM, he has fabricated everything from the beaching gear tail strut on an OS2U Kingfisher to the Parabellum machine gun mount for a World War I German aircraft. "The trick is to visualize what it [the part] is going to look like when it's done," he says. For the Seiran drift sight, he started with a long piece of aluminum tubing, fashioning the central body of the sight by turning the tube on a lathe, much as a woodworker shapes the leg of a chair. He monitored the lathe closely to ensure that the bits didn't overheat and that he did not remove too much metal; every couple of minutes, he stopped to check his progress. Says Vencelov: "Once you've removed the metal, you can't put it back."

ERIC LONG

After months of careful work, Vencelov is almost finished with the drift sight. The knobs function, the reflective sighting element looks perfect, and even a small handle acts just like the original—it doesn't quite lock into place on its own. To prevent confusing future curators and researchers, the new sight will be labeled "Reproduced by NASM" and a note placed in the Seiran's file.

When he's finished, the drift sight will be installed in the rear cockpit of the Seiran, and Vencelov will move on to some other project. Most people will probably never notice his work, which is as it should be.

—Scott Wirz

MUSEUM CALENDAR

April 8 Astronomy Fair. Local astronomy experts will teach you how to choose, use, and care for astronomical instruments. Meet at the Information Desk in the south lobby, 10 a.m.–4 p.m.

April 8 Evening Stargazing. Join National Air and Space Museum astronomer Sean O'Brien for a look at the spring sky's celestial sights. Activities will begin at dusk at Sky Meadows State Park near Paris, Virginia. For information and directions, call (540) 592-3556.

April 25 "Apollo and Lunar Evolution." The only geologist to walk on the moon, Apollo 17 astronaut Harrison H. Schmitt will discuss theories of the moon's origin. Langley Theater, 7:30 p.m.

April 29 "The Mystery of Time." Join amateur astronomer Jack Greenblat as he delves into the phenomenon of time as viewed by philosophers, physicists, and biologists. Einstein Planetarium, 6 p.m.

April 29–July 9 "Looping the Loop—Posters of Early Flight." This temporary exhibit features more than 30 aviation artworks from the Allen Airways Flying Museum. Gallery 211.

May 18 Charles A. Lindbergh Lecture: "Transonic Flight Testing—The Struggle to Break the Sound Barrier." Eric Brown, a retired captain from Britain's Royal Navy, will talk about the worldwide effort to break the sound barrier. Langley Theater, 8 p.m. Tickets will be available beginning April 11 through PROTIX, phone (800) 529- 2440, and on the Web at www.protix.com.

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.

Man Overboard!

At 9:30 in the morning on May 15, 1941, I stood in a crowd on a San Diego sidewalk, staring transfixed at the sky. We watched an R2D-1 transport circling, trailing a queer whirligig below its tail. The airplane, the Navy version of the Douglas DC-2, was marked "U.S. Marines." The whirligig was Marine parachutist Second Lieutenant Walter Osipoff. The drama that was about to unfold would be the talk of the town for weeks.

The lieutenant had been finishing up a routine practice drop. As jumpmaster, he had sent his 11 chutists and a cargo pack through the hatch, and was about to dump another cargo pack of rifles and ammunition and step out the hatch himself. As he attempted to push the 150-pound cargo container out, his rip cord got fouled with the rip cord of the cargo pack. When Osipoff's chute billowed open, he was yanked out of the transport. The weight of the cargo pack, together with the weight of the lieutenant and the pull of his parachute, put such a strain on the aircraft's static cable, which automatically opens the chutes of jumpers after they exit the aircraft, that the attachment bracket and bracing were torn off the transport. That ripped open the cargo chute, which billowed out the door and got tangled with Osipoff's parachute. Osipoff hung by his feet a hundred feet behind the transport in a net of shroud lines, static line, cable, silk, and harness.

Pilot Harold Johnson first knew there was trouble when a hammer blow hit him in the solar plexus. It was the control wheel. Johnson, wheezing, fought the controls as the transport's nose tilted up. The airplane felt so tail-heavy, he told me later, that he needed all his strength to push the nose down. Soon he realized why: Something—or someone—must have snagged on the tail. Johnson had no radio with which to call for help. But he could at least alert someone on the ground.

Flying as slow as he dared, 110 mph, he began circling gently over the Marine

PAUL SALMON

field at Camp Kearney, then over nearby Camp Elliott, and finally over the big naval air station at North Island in the harbor. At an altitude of a few hundred feet, he saw plenty of upturned faces. But what could anyone do?

Meanwhile, the five people left in the R2D tried valiantly to haul Osipoff back in. But progress was infinitesimal. All without parachutes, they too were in danger of slipping out the doorway.

Beneath them, twirling in the hurricane of the slipstream, Osipoff kept his eyes squeezed shut against the blast. A cargo hatch handle had torn open his left arm and shoulder. The shroud lines burned and lacerated his face and body. He was badly bruised all over and in shock from internal injuries. But Osipoff did not know any of this. He just knew he hurt all over. He kept his arms folded and legs crossed against the wind.

At the naval air station, Lieutenant William Lowrey was strolling toward a hangar when he glanced up and saw the R2D. "At first I thought it was one of those parachute dummies that were used to test parachutes with," Lowrey's fellow test pilot John McCants later told a military panel. Lowrey told McCants to gas up a small Curtiss SOC observation-scout biplane. Then he picked up a phone and called the control tower to explain his plan (the SOC had no radio either).

McCants signaled that the scout was fueled and started the engine. Lowrey sprinted toward it. From the barracks, Marines were sprinting too, knives in hand. "Cut his shroud lines," they yelled, tossing the knives in the cockpit.

The two Navy men took off and angled up toward where Osipoff was bouncing and flipping. The crew aboard the transport had by then managed to pull him a third of the way back in.

Suddenly Osipoff felt a wrenching smash. Something banged his aching back and shoulders. Then he was twirling again. Cautiously, he opened his eyes. Below him was the wing of another airplane.

From the ground, I could see that Lowrey had maneuvered the biplane under Osipoff, but the aircraft was whipped in the transport's slipstream and Osipoff twice got dragged across the wing. Lowrey then flew alongside the transport and signaled Johnson to try climbing to find calmer air. Soaked in sweat, Johnson let the nose come up again. He had enough fuel for another 10 minutes.

Time was shortening for Osipoff too. Being jerked through the hatch had broken his chest strap, and his leg straps were hanging on his ankles. "We could see that he was in pretty bad shape because there was blood dripping off the helmet," McCants later said.

At 3,000 feet Lowrey tried another pass. With McCants standing up in the rear cockpit, Lowrey got Osipoff lined up with the biplane's left wing and edged in, fighting to keep the propeller away from the jumpmaster's head. Then Osipoff was above the aircraft, almost close enough to reach. Ahead a little more. Up a little. McCants and Osipoff grabbed each other's waists and held on. Osipoff's head went into the rear cockpit. But he was still enmeshed in the lines, and try as he might, McCants couldn't make room for more than Osipoff's head. The cockpit was too small.

Osipoff lay on top of the fuselage, propped in a machine gun crotch aft of the second cockpit, clinging to McCants. Both were hampered by the shroud lines that were tangled in the static cable. Knife in hand, McCants sawed hard to cut Osipoff free. Each second counted—the two aircraft could not stay precisely in position for long.

Then a gust flung the SOC up. With a grinding scream, its propeller sliced 12 inches off the transport's tailcone fairing.

Lowrey told me later, when I interviewed all the players for a magazine article, that the impact dizzied him for an instant. He realized that by some miracle he was still flying, and so was the transport, a safe distance above him. Osipoff was still horizontal on the top of the biplane's fuselage. The parachute swirled behind, caught in the SOC's tail.

The collision might have been guided by angels. When the biplane's nose came up, the shroud lines fell across its upper wing, and the propeller neatly severed them when it sliced into the R2D's tailcone fairing.

Johnson glided the transport to North Island and landed safely. But Lowrey was in trouble. Part of the parachute jammed the biplane's rudder, leaving him with almost no rudder control. Clutching each other against the slipstream, Osipoff and McCants waited, hoping Lowrey could bring the airplane in.

Lowrey managed to bounce it onto the strip at North Island, chute and all, and was immediately surrounded by cheering crew.

Osipoff, who had endured 33 minutes of being dragged around the sky in a 110-mph wind, was promoted to first lieutenant after his release from the hospital. Secretary of the Navy Frank Knox presented Lowrey and McCants with the Distinguished Flying Cross for "extraordinary heroism…[in] one of the most brilliant and daring rescues within the annals of our Naval history."

—Keith Monroe

The Western Canadian Ramjet Co.

When I was 15 years old, I came across a magazine article explaining how jet engines work. It was 1947, and the technology was still fairly young. I showed the article to my buddy Walt. After perusing the cutaway views of turboprop, turbojet, and ramjet engines, we concluded that the ramjet was the simplest. "Hey, we can build one of those!" we said.

It so happened that our town, Enderby, in British Columbia, was putting in new water mains when winter struck. With the ground frozen, the workers were forced to leave four-inch-diameter pipes lying uninstalled along a couple of streets. We decided that for scientific purposes, Enderby should donate some of this material. We proceeded to liberate a length.

When we got it home, we drilled two holes, one on top and one on the bottom. In one hole we put a spark plug; in the other, quarter-inch copper tubing to serve as a fuel line. We connected the spark plug to an old tractor magneto on which we had mounted a crank for hand operation. From previous adventures we had acquired a single-burner gas stove with a built-in pump; we removed the gas tank and connected it to the fuel line.

Now we needed a source of moving air. We enlisted a couple of unsuspecting neighborhood kids and got them to blow into one end of the pipe. As they did, we injected a spray of gasoline through the fuel line and cranked the magneto, which caused the spark plug to ignite the gas. There was one problem: The heated gas flowed out both ends of the pipe, resulting in several singed eyebrows. Quickly running out of volunteers, we realized we needed a better source of air.

Walt had just completed a beautiful two-man bobsled, and we decided to enlist it in our project. We mounted the engine on two two-by-four outriggers on the right side of the sled. We fixed the magneto within reach of the "engineer"—the person who would sit behind the "pilot." The engineer would hold the gas tank between his knees.

One beautiful, bitterly cold Saturday morning, we took the sled up my snow-packed street. We reached a point where the road sloped down for almost a mile, then angled off to the right. Since Walt was the better sled driver, he became the pilot, and I was named engineer.

I pushed off down the hill, then scrambled aboard, taking my position with the gas tank clamped between my knees. I cranked on the magneto with one hand and pumped on the gas tank with the other. As we gathered speed, we were rewarded with a plume of flame out the tailpipe, and a delightful moaning.

We were probably doing about 30 mph when the fuel line broke at its juncture with the engine. Gas sprayed back over my leg and the aft end of the sled, then ignited from the engine's flame. We charged down the hill with fire streaking from my pants leg and the sled. "Stop this bloody thing!" I screamed.

Somehow we negotiated the hard right at the bottom of the hill, and Walt took us off the road and into a snowbank. I jumped off and jammed my leg into the snow, extinguishing the fire on my pants. Dumping snow on the sled, we put that blaze out too.

A survey revealed that the gasoline had burned only on the surface of my heavy wool pants and hadn't damaged the fabric. The sled showed only minor scorching.

Although we hadn't detected any significant thrust from our ramjet, the ride had been impressive. About a month later, while conducting further research, we read that most ramjets need to achieve a speed of about 375 mph to function properly. We never did find a hill steep enough.

—Gordon J. Twa

WAYNE SHIPP

"Our children must know that the future is theirs..."

PHOTO: ERIC LONG

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—AGNES BROWN

Museum docent Agnes Brown stands in front of the Douglas DC-3 on display in the Museum's Air Transportation Gallery. Her late husband flew this type aircraft during the invasion of Normandy and the Berlin Airlift.

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HUEY

If you remember Vietnam, you remember the Bell UH-1.

by John Sotham

Crude. Flying over Vietnam in a Bell UH-1 Huey meant a canvas seat in the back and hot, humid air whistling into the cabin around the pilots' doors.

Adaptable. Hang rockets on a Huey, grease-pencil an "X" on the canopy to aim by, and it was a gunship. Load it with casualties and it was an air ambulance.

Enduring. Today the Huey remains the most identifiable symbol of the Vietnam War—in everything from movies, where the noise of its rotors instantly sets the scene, to Broadway, where its silhouette represents the war on a *Miss Saigon* marquee.

In Vietnam, the military helicopter graduated from an underdeveloped promise to a formidable weapon. Among its peers, which included the aging, piston-powered H-19 and H-21, the HU-1, with its strong and reliable turbine engine, quickly earned a reputation for dependability and proved itself the best equipped helicopter to execute a new and mobile style of warfare. When the HU-1 went to Vietnam, it shed its given name, Iroquois, and took a moniker derived from the letters in its designation. Later, when the Department of Defense began using the Air Force naming standard, the letters were swapped and the helicopter became UH-1, but the nickname Huey stuck. Every branch of the U.S. military would soon be flying the rugged and versatile helo, as would the air forces of South Vietnam, Australia, and Cambodia.

But the cost of the helicopter war was high: The Army lost 2,249 to hostile fire—more than half of them Hueys—and 2,075 to accidents; the Marines lost 424 to all causes. Between 1966 and 1971, one Army helicopter was lost for every 7.9 sorties—564 pilots, 1,155 crewmen, and 682 passengers were killed in accidents alone. More Hueys were downed in Vietnam than any other type of aircraft.

For thousands of soldiers in Vietnam, the UH-1 Huey was the only way into—and out of—the battle (opposite). And still it serves: After 40 years of development, Hueys have gained a second engine and extensive avionics upgrades.

Slicks

The large-scale transport of troops to the battlefield by helicopter in Vietnam rendered World War II-style airborne operations, which relied on paratroopers dropping into hostile areas, obsolete—only one major parachute assault was conducted during the war. The Army centered its airmobile operations around Vertol CH-47 Chinooks and Hueys, referred to as "slicks" because they lacked external armament. Arriving in formations so tight that the rotors of neighboring helos overlapped, the slicks moved troops and equipment to the battlefield with unprecedented speed.

It was a solution born of its times. Modern adversaries are likely to be much better equipped than the Viet Cong—a few shoulder-fired missiles would stop a Vietnam-style air assault mission (flown at high altitude before spiralling into the landing zone) very quickly, says Robert Mason, who wrote *Chickenhawk*, a recollection of his experiences as a Huey pilot in Vietnam. "It proved it could work...," says Mason. "But it probably wouldn't happen again because [with the proliferation of weapons available] we wouldn't have a situation where we would have total air superiority." The Army and Marine Corps still practice air assault today, but only in conjunction with overwhelming fire support, and often while using Global Positioning System navigation, infrared terrain following, and night-vision goggles.

But for Huey pilots like Mason, troop insertion meant low-tech visual navigation to tiny landing zones over roads and other landmarks in a vast expanse of jungle, mountains, and hills, sometimes with only door-mounted machine guns for protection. Mason, who today is helping to develop a documentary about Vietnam helicopter flying for PBS, describes an air assault in *Chickenhawk*:

> I think this was my first as a commandship pilot, and I was for survival. I would've been very happy flying the brigade commander up there at 5,000 feet, or [General William] Westmoreland to his apartment in Saigon. It's amazing how many places I considered being besides there.
>
> In assaults, we usually started drawing fire at 1,000 feet, sometimes at 500. This time we didn't.
>
> At 500 feet, on a glide path to the clearing, smoke from the just completed prestrike by our artillery and gunships drifted straight up in the still air. There had to be one time when the prep actually worked and everybody was killed in the LZ [landing zone]. I hoped this might be it.
>
> Fighting my feeling of dread, I went through the automatic routine of checking the smoke drift for wind direction.

TED CARLSON; OPPOSITE—GILLES CARON/CONTACT PRESS IMAGES

None. We approached from the east, three ships lined up in a trail, to land in the skinny LZ. But it was too quiet!

At 100 feet above the trees, closing on the near end of the LZ, the door gunners in Yellow One started firing. They shot into the trees at the edge of the clearing, into the bushes, anywhere they suspected the enemy was hiding. There was no return fire. The two gunships on each side of our flight opened up with their flex guns. Smoke poured out of them as they crackled. My ears rang with the loud but muffled popping as my door gunners joined in with the rest. I ached to have my own trigger. With so many bullets tearing into the LZ, it was hard to believe anyone on the ground could survive.

The gunships had to stop firing as we flared close to the ground because we could be hit by ricocheting bullets. Still no return fire. Maybe they were all dead! Could this be the wrong spot?

My adrenaline was high, and I was keenly aware of every movement of the ship. I waited for the lurch of dismounting troopers as the skids neared the ground. They were growling and yelling behind me, psyched for battle. I could hear them yelling above all the noise. I still can.

My landing was synchronized with the lead ship, and as our skids hit the ground, so did the boots of the growling troops.

At the same instant, the uniformed regulars from the North decided to spring their trap. From at least three different directions, they opened up on our three ships and the off-loading grunts with machine-gun crossfire. The LZ was suddenly alive with their screaming bullets. I tensed off the controls, involuntarily leaning forward, ready to take off. I had to fight the logical reaction to leave immediately. I was light on the skids, the troops were out. Let's go! [Dan] Farris [Mason's squad leader] yelled on the radio for Yellow One to go. They didn't move.

The grunts weren't even making it to the trees. They had leapt out, screaming murderously, but now they dropped all around us, dying and dead. The lead ship's rotors still turned, but the men inside did not answer. I saw the sand spurt up in front of me as bullets tore into the ground. My stomach tightened to stop them. Our door gunners were firing over the prone grunts at phantoms in the trees.

A strange quietness happened in my head. The scene around me seemed far away. With the noise of the guns, the cries of the gunners about everybody being dead and Farris calling for Yellow One to go, I thought about the bullets coming through the Plexiglas,

GILLES CARON/CONTACT PRESS IMAGES (2)

Huey gunships carried side-mounted M-60 machine guns (above) to protect Huey "slicks" inserting troops and supplies into hostile areas (opposite, top). After the battle, the wounded often rode a Huey to a medical facility like that available at Da Nang (opposite, bottom). Helicopter transport saved thousands of lives.

through my bones and guts and through the ship and never stopping. A voice echoed in the silence. It was Farris yelling, "Go! Go! Go!"

I reacted so fast that our Huey snapped off the ground. My adrenaline seemed to power the ship as I nosed over hard to get moving fast. I veered to the right of the deadly quiet lead ship, still sitting there. The door gunners fired continuously out both sides. The tracers coming at me now seemed as thick as raindrops. How could they miss? As a boy, I made a game of dodging raindrops in the summer showers. I always got hit eventually. But not this time. I slipped over the treetops and stayed low for cover, accelerating. I veered left and right fast, dodging, confounding, as Leese had taught me, and when I was far enough away, I swooped up and away from the nightmare. My mind came back, and so did the sound.

"What happened to Yellow Three?" a voice said. It was still on the ground.

The radios had gone wild. I finally noticed Farris's voice saying, "Negative, White One. Veer left. Circle back." Farris had White One lead the rest of the company into an orbit a couple of miles away. Yellow One and Yellow Three were still in the LZ.

MARK GODFREY

I looked down at the two ships sitting quietly on the ground. Their rotors were turning lazily as their turbines idled. The machines didn't care, only the delicate protoplasm inside them cared. Bodies littered the clearing, but some of the thirty grunts we had brought in were still alive. They had made it to cover at the edge of the clearing.

Farris had his hands full. He had twelve more ships to get in and unloaded. Then the pilot of Yellow Three called. He was still alive, but he thought his partner was dead. His crew chief and gunner looked dead, too. He could still fly.

Two gunships immediately dove down to escort him out, machine guns blazing. It was a wonderful sight to see from a distance.

Only Yellow One remained on the ground. She sat, radios quiet, still running. There was room behind her to bring in the rest of the assault.

A grunt who found himself still alive got to a radio. He said that he and a few others could keep some cover fire going for the second wave.

Minutes later, the second group of three ships was on its way in, and Farris told me to return to the staging area. I flew back a couple of miles to a big field, where I landed and picked up another load of wild-eyed boys.

They also growled and yelled. This was more than just the result of training. They were motivated. We all thought that this was the big push that might end it all. By the time I made a second landing to the LZ, the enemy machine guns were silent. This load would at least live past the landing.

Somebody finally shut down Yellow One's turbine when we left. Nobody in the crew could.

Gunships

As effective as they were for getting troops and supplies to the battlefield, slicks were especially vulnerable to enemy fire as they neared the landing zone. Soon after the Huey's arrival in Vietnam, a few were outfitted with two .30-caliber machine guns and rocket

A Huey Family Album

HU-1B

HU-1Bs were the first Hueys to see widespread service in Vietnam and were often modified into gunships. Others flew as troop-carrying "slicks."

AH-1G Hueycobra

Built around the rotor and transmission system of a UH-1C, the sleek, rocket-slinging Cobra carried a 7.62-mm minigun and a 40-mm grenade launcher in a chin turret.

UH-1D

The D model had a more powerful engine, redesigned rotor, and larger troop compartment and was used primarily to carry troops to the battlefield.

ILLUSTRATIONS BY HARRY WHITVER

MARK GODFREY (2)

Vietnam saw an unprecedented use of helicopters to wage war, but at great cost—more than 1,200 Hueys were lost in combat. Some, like this UH-1 at Khe Sanh, were destroyed on the ground.

pods to escort assault landings and medical evacuation Hueys. Some were loaned to the Navy, which used them to support attack boats that patrolled the Mekong Delta. By 1963, factory-built UH-1C gunships began to arrive in Vietnam. The UH-1C could also be fitted with a chin-mounted 40-mm grenade launcher or M-60 machine gun, as well as 20-mm cannon pods, often through field modifications.

But all that hardware came at a cost. Pilots of Huey gunships had difficulty keeping up with the speedier slicks they were supposed to escort. Loaded down with guns and ammunition, the lifting power of a UH-1C gunship "could hardly pull the slack out of your shorts," says Jeff Stayton, a helicopter pilot who flew in Vietnam and is now the director of the Army's Test and Evaluation Command.

In 1966 the Army quickly fielded a private venture from Bell, a purpose-designed gunship with the same transmission and rotor system as the HU-1C. The new Hueycobra, flown by the Army and Marines, was armed with 3,000 pounds of rockets, grenades, guns, and ammunition but was nearly twice as fast as a Huey.

Bob Drury flew Hueycobra gunships in 1969 and 1970 from Chu Lai, an air base located about 90 miles south of Da Nang in South Vietnam. One mission sticks in his memory more than any other:

Drury had told the Dustoff (medevac) pilot exactly what to do. The best flight path into the LZ for the unarmed medical evacuation Huey was above the trees—they'd block the enemy's sight and limit his line of fire.

But the Dustoff pilot didn't heed the warning; he flew over a rice paddy, was hit, and crashed. Fortunately, the crew survived and was picked up by another Huey. A second Dustoff picked up the wounded and hastily left the LZ while Drury and his fellow Cobra pilots kept a careful watch and softened up the treeline with their rockets.

More than 25 years later, even while Drury is at home in Iowa with his wife and three children, the exasperation quickly rises in his voice as he recalls that day. "My first reaction was, 'You dumb son of a bitch. I told you to stay over the trees.' But in defense of him, that's what he had been trained not to do. That mission sticks in my mind because it was the only time I lost a Dustoff. Gunship pilots had the feeling that our job was to protect those people. When we couldn't do our job, it was unbelievably frustrating, and if we lost a ship, it was just gut-wrenching."

Gunship pilots like Drury flew a variety of missions, including visual reconnaissance, fire support for ground operations, and escort for troop-carrying slicks and Dustoffs evacuating the wounded. "The adrenaline rush that goes with flying those missions is incredible," Drury says. "You've got so many things going on in the cockpit and there are so many things going on around you."

The Cobra was a tremendous improvement over Huey gunships, but to exploit the Cobra's strengths—speed and more armament—teamwork was the most effective approach, Stayton says. "When we did a battalion-level combat assault, we could provide optimal protection with four C-model [gunships], two on each side, with M-model [gunships] behind and to the side and Cobras at 1,500 to 3,000 feet overhead. The Cobras could use their diving capability to pinpoint and snuff out any fire. "

Dustoff

Early in the Vietnam War, when comparatively few troops were on the ground, wounded soldiers were usually evacuated by the same assault helicopters that brought them to the battlefield. But as troop strength increased and the conflict escalated, this space-available method proved inadequate. In response, the Army began to train pilots and crewmen in basic emergency medicine and trauma management and assign them to fly rescue missions in unarmed helicopters marked with red crosses. "Pilots learned to give shots, about saline solutions for wounds, and

DAVID BURNETT/CONTACT PRESS IMAGES

The Hueycobra was a flying gun platform based on a Huey engine and transmission and was better able to escort air assault landings. For these refugees displaced by nearby fighting in the Vietnam highlands, a Huey offered the only ticket to safety (below).

As Saigon fell in late April 1975, South Vietnamese military personnel and their families fled to American carriers like the USS Blue Ridge. *After landing, the empty Hueys were quickly dumped over the side to clear the decks.*

about burns and the basic elements of first aid," says Dustoff pilot Michael Novosel. The radio call sign "Dustoff"—randomly selected from a code book, became the universal call sign in Vietnam for helicopters flying medical evacuations.

Dustoff pilots in Vietnam benefited from an unusual pilot in their midst. At the age of 44, Novosel was at least 20 years older than most of his peers, and at five foot four, considerably shorter. He had flown B-29s in the Pacific during the final days of World War II, and was serving as a lieutenant colonel in the Air Force Reserve when he tried to return to active duty to train pilots Stateside. The Air Force refused him, saying he was both too old and too senior, so he tried the Army. The Army sent him to Vietnam to fly Dustoffs. Novosel became a warrant officer like most other Army helicopter pilots, a rank that meant he'd have to salute even a lowly second lieutenant. "I just wanted to help out," he says. "I certainly didn't think that I'd be in combat." Because of his total flying time—greater than twice the combined time of every pilot in his unit—he was perfect for teaching instrument-flying procedures needed for missions flown at night or in bad weather, and was in a unique position to shape doctrine for the entire Dustoff community. "There was no flight training designed specifically to help Dustoff pilots," he says. As more pilots looked to Novosel for guidance and training, he became widely known throughout Vietnam for his skills. "Some units had better training than others," he says. "I became the unofficial instrument pilot trainer toward my first year [in Vietnam]."

All helicopter flying in Vietnam was risky, but Dustoff flying was the most dangerous of all: Between 1962 and 1973, 207 medical evacuation crewmen were killed, even though there were never more than 140 dedicated air ambulance helicopters flying at any single period during the war. Despite the hazards, an average American serviceman could expect to be airlifted to a hospital environment less than an hour after being wounded—and fewer than one percent of soldiers who survived 24 hours died.

On October 2, 1969, Novosel was well into his first tour in Vietnam. He was stationed at Binh Thuy, South Vietnam. Late in the afternoon, after having already spent seven hours in the air, he was directed to a casualty pickup 30 minutes away on the Cambodian border. Numerous wounded

South Vietnamese troops, left behind by their unit and out of ammunition, were surrounded by the Viet Cong in a swaying sea of elephant grass. There were no aircraft available to provide covering fire for Novosel's unarmed Huey. All directions came from an orbiting helicopter and Swamp Fox 15, an O-1 Bird Dog observation aircraft flying nearby. Without friendly forces on the ground, the situation was completely out of control—according to the regulations that governed Dustoff missions, Novosel was to leave the area immediately.

Novosel's crew had heard the report from the circling aircraft but remained silent on the intercom, which Novosel took for a commitment to any decision he made. He pushed the Huey's nose over and swooped toward the ground, aiming for where the spotter aircraft reported sighting a downed soldier.

Automatic weapons fire opened up from all directions, and the soldier was nowhere to be seen under the fans of elephant grass now flattened under the rotor wash. Novosel quickly climbed out of danger. After another unsuccessful attempt, he began to fly racetrack circles just above the tops of the grass. Finally, a Vietnamese soldier stood and waved a shirt.

Crewmen Herbert Heinold and Joe Horvath quickly grabbed the soldier and pulled him into the Huey. Soon, other figures began to rise from the grass and were quickly hauled aboard. Novosel had to climb above the gunfire many times, only to dive toward the ground again to resume his search. Within minutes, the Huey held 10 soldiers. Novosel flew to a nearby special forces camp at Moc Hoa to deliver the wounded and refuel. Then he went back.

The remaining troops now eagerly waved their arms to attract Novosel's Huey, including one soldier who ran toward the helicopter while holding his intestines against his body. Others were cut down by Viet Cong machine guns as they rose. Novosel's Huey, riddled with holes, continued to fly. On his third trip, he got air cover from Air Force F-100s and Army AH-1 Cobras, and after rescuing nine more soldiers, Novosel prepared to depart until a 10th soldier rose from the grass, barely visible in the failing light. Novosel positioned his Huey so the most intense fire was coming from the rear and backed the helicopter toward the soldier while his crew lay on the deck. Horvath hauled the man aboard, and as Novosel prepared to gain forward speed and jerk the Huey into a climb, a Viet Cong soldier rose from the grass and emptied a clip from his AK-47 into the cockpit. The helicopter careened across the grass until copilot Tyrone Chamberlain could gain control and climb the helo into the sky. Incredibly, neither pilot was seriously injured, but shrapnel from the bullets tore into Novosel's leg. After offloading the wounded, Novosel and his crew returned to their base. That day, they had spent 11 hours in the air.

In 1970, safely back in the United States and assigned as a pilot for the Army's Golden Knights parachute demonstration team, Novosel answered a phone call from a Pentagon major who began the conversation by asking him to sit down. Novosel was to receive the Medal of Honor for his actions on that terrible afternoon three years before. Novosel and his crew had saved 29 men from certain death—a mere fraction of the 5,589 wounded soldiers he had evacuated during two tours in Vietnam.

Today, nearly 30 years after the Huey's introduction, crews still fly the venerable old choppers, but the airframes are tired and are being replaced by newer types like the UH-60 Blackhawk. While the Marines have plans to upgrade their comparatively small Huey fleet with a four-blade rotor system, new T700 engines, new avionics, and an auxiliary power unit, the UH-1 has almost disappeared from the active Army inventory, although it still flies in the reserve and national guard. "But us old Huey pilots have a saying," says Jeff Stayton. " 'When the last Blackhawk goes to the boneyard, there'll be a Huey crew there to pick them up.' But don't get me wrong. The Blackhawk is a superb helicopter. But there's just a soft spot for the Huey. I mean, look at it—the UH-1 has been flying for 40 years. It's the DC-3 of the helicopter world."

The legacy is clear—no longer just a hauler of beans and bullets, helicopters have firmly taken their place on the battlefield, led by a simple and redoubtable standard bearer that could do it all.

Endangered? The Huey has nearly disappeared from the active Army inventory, replaced by the UH-60 Blackhawk. This Marine Corps UH-1 flying over the California desert is luckier—more powerful engines, a four-blade rotor system, and new avionics are coming soon. Semper torque!

TED CARLSON

HIGH

A DC-3 airframe is stripped bare before the aircraft is reborn as a BT-67. Opposite: The metamorphosis occurs at the Basler plant in Oshkosh, Wisconsin (inset). A hundred DC-3s are still earning their keep in North America, many hauling freight, like this one flying to Catalina, California.

MILEAGE

Just how many hours can you wring from an airplane? Ask the operators, mechanics, and parts suppliers who keep DC-3s in the air.

by Mark Huber *Photographs by Chad Slattery*

A 40,000-hour DC-3 sits in the grass at Hook Field in southern Ohio, ready to start the night shift for Miami Valley Aviation. Paint is peeling off the nose, and what remains on the rest of the airplane is faded and filthy. The windshields leak. Inside the cockpit, a lip on the instrument panel catches incoming precipitation. It inevitably overflows onto the upper left pant leg of the captain. "When you get out of the airplane, it looks like you've been scared real bad," says Miami Valley chief pilot Kevin Uppstrom, who has 10,000 hours in DC-3s. The engines leak too. Oil and exhaust have trailed black streaks across the top of the wings, and black pools often form below them.

It wasn't always so. Serial number 42-93518 rolled off Douglas Aircraft's Oklahoma City assembly line in May 1944 as a C-47A, a military variant of a DC-3, joined up with the Ninth Air Force the following month, and by October 1945 was declared surplus. Re-christened the *Sam Houston*, it flew passengers for Dallas-based Pioneer Airlines between 1946 and 1952, then rejoined the Air Force as a C-117C transport. For the next 20 years it remained in government service. Miami Valley acquired it in 1989, and now tail number N36AP, along with five other DC-3s operated by the company, hauls freight. Tonight's critical cargo is packed in crates lashed to the floor: automobile bumpers.

On any given night (or day), from Middleton, Ohio, Charlotte, North Carolina, Miami, Salt Lake City, Oakland, or Fairbanks, DC-3s fly low and slow, stuffed with auto parts, drums of diesel fuel, blue jeans, machine tools, medical supplies, your mail, and virtually any other commodity con-

trolled by the canons of just-in-time inventory and cash flow management. Sixty-five years after it first flew, the DC-3 is still one of the cheapest ways to move loads of up to three tons, especially over distances of less than 500 miles.

For an operator like Miami Valley Aviation, the basic math is inescapable. Good DC-3s with mid-time engines can be had for around $150,000, the same price as a new Cessna Skyhawk four-seat, single-engine trainer. The "-3s" have direct operating costs a little less than those incurred by a B200 King Air twin turboprop: about $600 to $700 an hour. Hanging rebuilt engines on a DC-3 costs, at $35,000 to $45,000 a side, about the same as re-engining a twin-piston, six-seat Beech Baron. And each of these airplanes has only a fraction of the carrying capacity of the DC-3.

That's one reason it's still in harness. According to aviation historian Henry Holden, author of *The Legacy of the DC-3*, about a hundred DC-3s are still in service with U.S. revenue-producing operations. Another 200 are still flying on this continent simply because the airplane is a celebrity. The DC-3 did for commercial aviation what the Model T did for the automobile industry, according to Ron Davies, a curator at the Smithsonian Institution's National Air and Space Museum, who worked at Douglas (and later Mc-

(Top) A Basler technician installs a new kit of alignment pins and latches for attaching a radome where the old metal nose used to be. The kits come from Basler's parts room, where materials manager Pat Keesler presides. In this room alone, Keesler keeps over 6,500 parts in stock.

Turbine-Charged

The hulks of seven DC-3 fuselages are parked alongside Basler Turbo Conversions' 75,000-square-foot facility in Oshkosh, Wisconsin. Three more DC-3s sit inside, disemboweled, bracketed by yellow scaffolding in a main hangar that looks like a surgical theater. With them, a shiny white and blue BT-67, a "Basler-ized" DC-3, awaits its new owner. Fly-away price: about $4 million.

Since 1990 Basler has given new life to dozens of DC-3s. (In the 33 years prior to that, Basler Flight Service had reworked more than a hundred DC-3s, modifying interiors, restoring airframes, and overhauling engines.) Basler installs Pratt & Whitney Canada PT6A-67R turboprop engines and Hartzell five-blade metal propellers in place of the piston engines and props that powered the original aircraft. The company increases the DC-3's volume 35 percent by inserting a 40-inch plug in the fuselage forward of the wing and moving the cabin bulkhead forward five feet. A BT-67 boasts 45 more mph of cruise speed and almost 4,000 more pounds of useful load than the original DC-3.

The aircraft's notoriously temperamental 14-cylinder piston radial engines have always been seen as its weakest feature, so hanging turbines on DC-3s is not a new idea. The British tried it at the end of the 1940s using Armstrong-Siddeley Mamba and Rolls-Royce Dart turboprop engines. The engines helped, but the unpressurized aircraft couldn't be flown at an altitude that would use the engines to their best advantage, and the project was quickly dropped. The idea was resurrected in the 1960s: In California, a few "Super Turbo Threes" were made and sold, but that project also fizzled. A Taiwanese venture failed as well.

One of the most interesting turbo conversions was done by aviation legend Jack Conroy in the 1960s. His modified DC-3 initially featured three Dart engines, two on the wings and one stuffed in the nose. He sold the airplane to the Specialized Aircraft Corporation, which replaced the engines with Pratt & Whitney models. DC-3 experts then trace the Tri-Turbo to Santa Barbara Polair, Inc., which leased it to the U.S. Navy as a ski-equipped arctic research aircraft. Some have suggested it flew missions for the CIA. The late Warren Basler bought the aircraft in 1992 from a salvage yard in Tucson. It was so distinctive that Basler insisted it be preserved as an important part of the DC-3's history, and today it sits in Oshkosh, stripped and weathered, awaiting rebirth.

In addition to converting the engines and extending the fuselage, Basler installs new electrical, hydraulic, and fuel systems, reinforces the wings and fuselage to handle the aircraft's increased gross weight, upgrades avionics to current standards, and modifies the wingtips and the leading edges on the outboard sections of the wings to improve stall characteristics. A fully loaded BT-67 has a slower approach speed than a comparably loaded DC-3.

Basler will convert an owner's existing airframe or provide an airframe for conversion. In the latter case, the company looks for "low-time" (less than 40,000 hours) airframes with relatively little corrosion and a good maintenance history. Some are trucked in. Corroded parts are replaced. A Basler-converted airframe is considered to have "zero time" with respect to mandated inspections.

The company fitted five BT-67s in gunship configuration with forward looking infrared (FLIR) cameras that could be slaved to .50-caliber machine guns and sold them to the Colombian air force to fly drug interdiction missions. The government of Mali has used its BT-67 to transport U.N. Secretary-General Kofi Annan to Timbuktu. And last year a freshly minted BT-67 on skis began flying adventurers to Antarctica. Other Basler conversions fly a variety of missions around the world: Six are used for rainmaking in Thailand, and two are flown by the U.S. Forest Service to drop smokejumpers in Montana. The Basler operation has become so well known that the company constantly gets calls from DC-3 operators looking for parts.

The major modifications that Basler makes to the DC-3s are done under a Supplemental Type Certificate. The FAA has also granted the company Parts Manufacturing Authority for the parts it manufactures in-house. A substantial part of the PMA is related to the new electrical and fuel systems. The FAA's Manufacturing and Inspection District Office has manufacturing oversight.

Last summer Basler president Tom Weigt had one of the ski-equipped BT-67s on static display during the Experimental Aircraft Association's annual fly-in in Oshkosh, Wisconsin. A few visitors took umbrage at the turbine conversion, asking Weigt, "How could you do that? How could you do that to that beautiful airplane?"

Weigt says that they were in the vast minority. "Most people recognize it for what it is," he says. "We build *new* airplanes. Rugged and simple airplanes."

BT-67s fitted with infrared cameras (visible under the noses) fly over Wisconsin farms before heading for work with the Colombian air force.

COURTESY BASLER TURBO CONVERSIONS

Donnell Douglas) between 1968 and 1981. "By 1940, 87 percent of the commercial airplanes flying in the United States were DC-3s and the remainder were largely its progenitors, the DC-2s," says Davies. And, he adds, pilots loved the airplane. "Its performance on the ground and in-flight is excellent and has never been equalled," he says. For pilots, few airplanes were as straightforward. "If you could taxi it, you could fly it." But the aircraft wouldn't fly today for love or money were it not for an abundant, if disparate, supply of parts and support.

"I can buy good, low-time DC-3 airframes all day for $90,000," says Pat Keesler, materials manager and resident parts impresario for Basler Turbo Conversions in Oshkosh, Wisconsin. For every DC-3 in the air, Keesler estimates that there are another four sitting derelict somewhere, just waiting to be cannibalized. Douglas built almost 11,000 DC-3s and C-47s between 1935 and 1945 and licensed manufacturers in Russia and Japan, which together produced at least another 4,000. Over the years, Basler has acquired DC-3 airframes from Arizona boneyards and from Canada and has also found them as far away as Africa, France, New Caledonia, and Thailand.

Since 1990, Basler has been "remanufacturing" DC-3s under its own Supplemental Type Certificate, an amendment to the Federal Aviation Administration's specification for a particular aircraft type. In the course of six months, a DC-3 undergoes 32 major changes on its way to becoming a BT-67 (see "Turbine-Charged," previous page). Besides the extensive modifications, Basler replaces corroded parts with new ones, and Keesler's job is to keep the parts available while maintaining a minimal inventory. Not a problem, as far as he's concerned. "There are a lot of guys out there with barns and warehouses full of this stuff waiting for their ships to come in," Keesler says. "Well, they're going to have to wait another 50 or 60 years. There are more parts out there than there is a market for." Keesler gets most of the parts he uses from a supplier he refers to as "the Bobs."

Bob Westbrook and his employee Bob Autry run Standard Aircraft Parts out of a 25,000-square-foot warehouse and Quonset hut complex in Ontario, California. Westbrook started Standard in 1962 after working on C-47s for Southern California Aircraft Company during the Berlin Airlift. Today, Standard supplies airframe parts for DC-3s, -4s, -6s, and -7s, but sells more DC-3 parts than anything else.

Westbrook is proud of his low-overhead location and the fact that in 37 years he has never bought a single trade advertisement. People who operate DC-3s know where to find him. His company owns a single computer; Westbrook's wife uses it for billing. Standard's inventory of 150,000 parts is tracked on Kardex, a file card system akin to a library's card catalog and somehow appropriate for a 1930s-era parts inventory. "It works fine for us," he says.

After Boeing acquired McDonnell Douglas in 1997, it sent out a letter announcing termination of product support for the DC-3 and pointing operators to Standard. Eight years ago Standard bought Douglas' remaining DC-3 airframe parts inventory and tooling. "Thirty-three truckloads on a 20-foot bobtail truck," Westbrook says. He took everything: ailerons, elevators, wingtips, gas tanks, rudders, bearings, bolts, brackets, and washers. Over the years he has also acquired parts inventories from the air forces of Australia, Argentina, Canada, Denmark, France, and South Africa and has sold them back to South Africa and Australia (and repurchased some of those).

Standard counts a hundred active DC-3 clients (those who have purchased parts within the last six months) and a thousand inactive. They call from as far away as New Guinea. Business, Westbrook says, has never been better. He knows he picked a winner. "This is the best airplane ever made," he says. "If you give some of these smaller operators jets, they wouldn't know what to do with them. This airplane was designed so you could get to parts and replace them whole. It's like working on an old car."

From the beginning, Westbrook has stocked small, easily transportable parts—"Those are the things that wear out the fastest: bearings, bolts, and brackets," he says—and he figures his inventory will last for at least 10 more years. "We

NASM. OPPOSITE—COURTESY DELTA AIR LINES

American Airlines, the first to order DC-3s, was among the first to line them up for sale after World War II. When Douglas' parts inventory went up for sale 50 years later, the "Bobs"—Westbrook (top, left) and Autry—of Standard Aircraft Parts bought it all. Bob Westbrook Jr. (bottom) helps stow one of 150,000 parts. One of Standard's customers, Delta Air Lines, recently restored a DC-3 inside (opposite) and out.

don't keep a lot of the large stuff, like stabilizers," says Westbrook. For those, the road leads to San Antonio.

Tradewinds Aircraft Supply got into the DC-3 business in the mid-1960s, when Trans Texas Airways dumped their DC-3s for Convairs. Tradewinds bought up Trans Texas' inventory of 22 aircraft and spares, then augmented that by purchasing a large DC-3 parts inventory from a Dallas broker. Today, Tradewinds sells DC-3 airframe parts "from nose to tail" worldwide, according to manager Richard Ormond. He stocks 20,000 line items and, like Standard, keeps track of it all on Kardex.

There are endless variants of and modifications to DC-3s—The military alone made more than 50 modifications to the C-47—and Ormond thought he had seen them all until a customer called looking for a left-hand aileron trim tab for a DC-3 then owned by Dow-Corning. Ormond patiently explained that DC-3s weren't made with left-hand trim tabs; in response, the customer sent him a photo. "They had the only DC-3 made with a left-hand trim tab," he admits. More common modifications are main landing gear doors and oversize engine cowls and oil coolers, which Ormond stocks, and shortened, squared-off wingtips, which he doesn't.

Although Standard Aircraft Parts, Tradewinds, and other established parts houses have the largest supply of DC-3 parts, for some parts, operators can also find cheaper sources. Basler's Keesler shows me a crate of new landing gear oleos—landing gear legs with shock absorbers. They came from a source who faxed Keesler out of the blue, announced he had oleos, and suggested that Keesler "Make offer." Keesler says he gets lots of faxes offering grosses of DC-3 airframe parts, some with deals so good that he buys the inventories sight unseen. He does business with a half-dozen hoarders regularly, none of whose names he will reveal. "There are a lot of people out there who want to know who these guys are. I ain't about to educate 'em," he says.

James Ray, manager of museum restoration programs at Delta Air Lines, is similarly taciturn when asked about parts suppliers for Delta's newly restored DC-3, number 3278 (see "Delta Queen," next page). Ray built his own database of approximately 50 parts suppliers during the DC-3 restoration and previous Delta projects, including the restoration of one of two remaining Travel Air S-6000-Bs, the airline's first aircraft. It's obvious that there's competition for the smaller parts suppliers, and finding them can involve time-consuming detective work. "A lot of the principals who have parts rat-holed aren't on the Internet," says Ray, though the Internet can be a useful source, he says. He found 20 percent of the parts he used in the DC-3 restoration there, including an authentic, fabric-covered cord for the galley telephone. "The Internet is also a great place to find aging aircraft Airworthiness Directives and virtually everything we need to know about the airplane," says Ray. For everything operators need to know about the airplane's engines, there's another resource.

Precision Engines in Everett, Washington, is one of the world's most respected overhaulers of radial piston engines. It holds FAA Parts Manufacturing Authority for over 1,200 Wright and Pratt & Whitney radial engine parts, including

Delta Queen

James Ray is futilely trying to eat his breakfast biscuit before it cools to room temperature. Ray is manager of museum restoration programs at Delta Air Lines and today is the big day. In a few hours, after four years of work, what may be the world's most extensive restoration of a DC-3 will be presented to Delta's employees. Here at Atlanta's Hartsfield International, in Delta's first hangar, sits its second DC-3, number 3278, returned to its original (and flyable) magnificence of highly polished aluminum, wool upholstery, and dozens of toggle switches. Washed in the glow of stage lights and framed by multi-colored buntings hung from the rafters, the airplane is making its debut in its public relations and marketing mission, which includes eventual flights to Delta hubs around the country.

Amid the cacophony of last-minute preparations, Ray slides a photograph across his desk. It appears to be of an airplane. A tail number is visible: N23PR. The faded blue and gray paint is highlighted with what looks like tar around the window seals. Prodigious puddles have formed under the wings. It looks every bit its 78,000 hours. Amazingly, this is the same airplane now sitting resplendent in the hangar.

Number 3278 joined Delta on December 23, 1940, and left the airline in 1958. After that it was downhill: Two private owners, then seven years with North Central Airlines, then new owners every year or every other year until 1980. Since then, it had been an island-hopping freight dog for Sixto Diaz Saldana of Puerto Rico, parked outside in a salt water environment. Ray states the obvious: "It was in very rough shape."

Shortly after 3278's arrival in Atlanta in 1993, so was Delta. The airline had run up $1.8 billion in losses in three years. Dropping an undisclosed amount of money to give flight to nostalgia seemed imprudent, and the project was shelved. But Delta rebounded, and by 1996 the decision was made to make the aircraft airworthy.

Corrosion was everywhere, even in the overhead panels. "The deeper we got, the worse it got," says Ray. The vertical tail had to be rebuilt. All of the sheet metal and skins were replaced. The windshield and door frames were rebuilt. New aluminum window frames were painstakingly made from scratch. Parts for the main cabin door handle had to be machined. It took three years to find and overhaul some of the seat parts for the original 21-seat cabin configuration, in which two seats were on one side of the aisle and one was on the other. The restoration crew had access to drawings in the Douglas archives, but some parts of the aircraft—the galley and lavatory—had to be reconstructed from photographs.

At first the work was done mostly by volunteers, who brought in old maintenance and operations manuals to use as references. John Mitas, who worked on DC-3s for Delta from 1948 to 1962, was among them. What started as one day a week for Mitas quickly became five. He scavenged parts, polished, and worked on the avionics, electrical wiring, and tubing. Mitas walks around to the cabin door, which seals with the precision of a bank vault, thanks to the year-long effort of another volunteer, Bill Stapely. Delta staff member Scott Gerken, who "wired every square inch of that airplane," according to another staffer, says that the retirees were the heart of the project.

When it was time to show off their work, the museum staff, dressed in 1940s-style maintenance and crew uniforms, stood by the aircraft and fielded comments from hundreds of Delta employees, current and retired, as big band music filled the hangar.

The DC-3 will be on view for the rest of us this July at the Experimental Aircraft Association's Oshkosh fly-in.

COURTESY DELTA AIR LINES

It took volunteers and the staff of Delta's museum restoration programs four years to restore the airline's second DC-3. Below: Connie Morgan searches the Kardex catalog at Standard Aircraft Parts for information on an engine mount bushing.

COURTESY DELTA AIR LINES

those for the R-1830 Twin Wasp, the engine used on most DC-3s. (Wright engines powered some early DC-3s; however, the R-1830 showed up in 1936, and all C-47s used it.)

Every other year Precision sponsors the World Radial Engine Symposium in an effort to answer customer questions and urge proper maintenance and operating procedures. The last symposium attracted 120 participants from around the globe. While some were hobbyists and warbird buffs, the vast majority were revenue haulers. One of them was Don Elliott, the director of maintenance for Miami Valley Aviation and its fleet of six DC-3s.

"They take a lot of oil," says Elliott, who was reminded at the symposium of one of the things he experiences almost daily in the field: With oil starvation the chief engine killer, the engines must be pre-oiled before each flight. An electric motor is used to pump oil into the engine before it's started. Even with this precaution, only 50 percent of the engines will run without help for 1,400 hours, the FAA's "Recommended Time Between Overhauls" for the R-1830.

"Our new pilots don't believe me when I tell them, on average, they will shut down an engine in flight every 500 hours," says Miami Valley's Kevin Uppstrom, who has more than a little experience with single-engine DC-3 flying. Then, of course, there's the natural temptation to push the remaining engine too hard, which often results in *its* failure on the next flight out, according to Uppstrom.

"I've pulled 'em off everywhere I can think of," says Elliott. "We've got it down to a science."

Premature engine death can boost DC-3 hourly operating costs into the range incurred by a light corporate jet and

NASM, OPPOSITE (COLOR)—COURTESY DELTA AIR LINES

In the 1930s two symbols of American ingenuity graced the sky over Manhattan: the pinnacle of the Empire State Building and the pride of the U.S. civil fleet. Opposite: Delta's new old airliner, before restoration and after.

is the main reason virtually all operators using the airplane for passenger service or sightseeing rides have abandoned it. (Freight operators can generally charge more and therefore survive the economic bite inflicted by unpredictable engine life.) An R-1830 engine that is lovingly coaxed to its overhaul time usually costs around $30,000 to rebuild. Salvaging one that scatters from abuse starts at $45,000.

"The engine situation is what's killing the airplane," says historian Henry Holden. "There comes a point [after multiple overhauls of the same engine] that you just can't get pressure out of the cylinders anymore."

Somehow, the DC-3 labors on. "Ten years ago, I would have said they're going to be gone in ten years," says Miami Valley's Don Elliott, whose company flies freight in a $2 million Falcon 20 jet and four Beech 18s; it also owns two Learjets, a King Air 200, and three Piper Aztecs. "The DC-3s have bought us everything we have here," says Kevin Uppstrom, and Elliott agrees.

At least part of the reason for its long life could be a sentimental attachment to an airplane that made history. Elliott says that every time he goes to an airport to work on one of the DC-3s that lost an engine, people of all ages stop to watch, and oldtimers tell him stories of the first time they flew—always, it was in a DC-3. So, are the revenue operators hanging on for sentimental reasons?

"Nah," says Elliott. "It's the fact that they can still make money with them. We still get over a thousand hours a year out of them."

Elliott thinks the engines will soldier on, but he's not sure the airplane will survive federal regulations. "I heard at the Precision engine symposium that the EPA was [considering a ban] to say absolutely no more lead. My biggest concern is that they'll outlaw 100-octane standard aviation fuel."

Mike Hudon, product support manager for Precision Engines, sees a different threat to the DC-3's survival. "There are plenty of parts and pieces out there," he says, but the number of people with experience in DC-3 maintenance and operations is declining. In other words, the aircraft's institutional memory is fading.

To spread the knowledge of DC-3 operations to those unable to attend Precision's engine symposium, the company distributes a maintenance and operating video, including a fascinating post-mortem that graphically demonstrates the damage caused to metal (and wallet) by a host of stupid pilot tricks, including chop drops—pulling the throttles back and letting the propellers drive or "reverse load" the engines during aggressive descents—closing cowl flaps to expedite engine warm-up, and setting improper manifold pressure. As the offenses are recited, the abused engine components flash onto the screen: scored blower seals, wrecked pinion teeth, scuffed bearings, carbonized valves....

Sharing this knowledge becomes more urgent as DC-3s are increasingly flown by a generation of young, time-building pilots whose only previous exposure to radial engines may have been in a museum and who fly for companies whose customer mantra is "How fast can you get it to me?" But that generation is also key to the airplane's survival.

At 24, Miami Valley Aviation pilot Chris Price flies an airplane more than twice his age. He wanted to fly DC-3s so bad that he made three trips to Ohio from his native California on his own dime and basically badgered Kevin Uppstrom into hiring him. In the cockpit of tail number N36AP, Price notices a grass-skirted hula doll atop the instrument panel, a fellow pilot's lucky talisman. He carefully removes it before throwing the sequence of switches on the overhead panel to start the engine. "It's a lot like playing a guitar," he says of cranking the giant, 1,200-horsepower radials. "Starter, count nine blades of rotation, mixture forward, boost pumps, magnetos. Works nine times out of ten.

"My friends are all going to work for the commuters" on their way to careers with the major airlines, says Price. "Before I did that, I had to be here. This sets you apart from the rest of the crowd."

A few weeks later at a Delta hangar in Atlanta, John Mitas, 78, who first turned a wrench on a DC-3 in 1948 for Delta Airlines, reflects on the restoration project he's just participated in. Toward the end of the four-year project, the team couldn't find a key for the aircraft's cabin door. Mitas remembered he had held on to his DC-3 cabin door key from 50 years ago. In fact, he still carried it on his key chain. But number 3278 had run through 11 different owners since Delta sold it in 1958. Surely someone had rekeyed that lock. On a lark, Mitas tried his DC-3 key in the door. It worked perfectly.


Delta


Delta


Delta

An annual airshow featuring such sexy aircraft as the English Electric Lightning is part of an entrepreneurial vision to turn the South African coastal city of Cape Town into the Oshkosh of military jets.

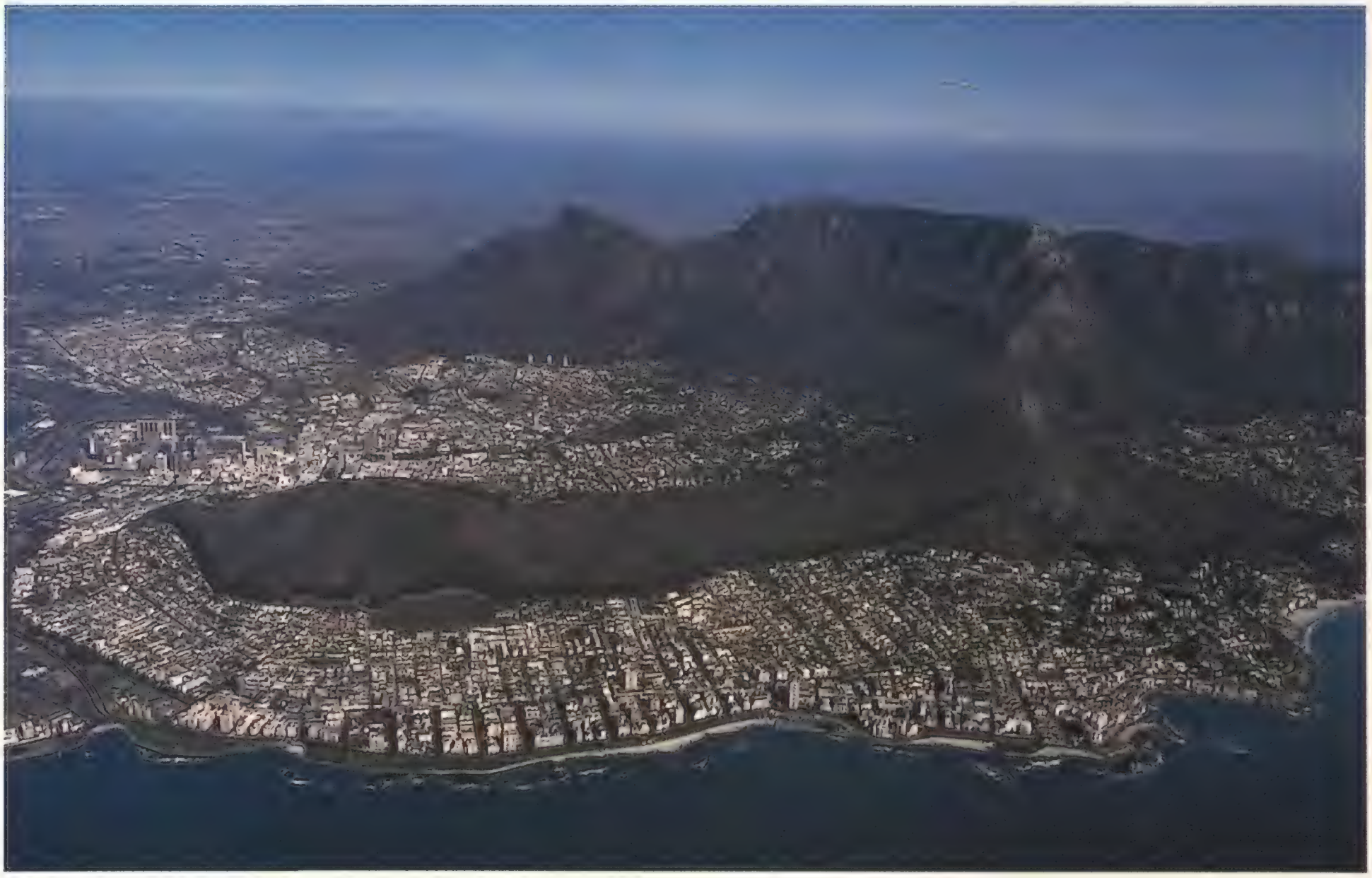
LIGHTNING STRIKES

CAPE TOWN

Rare high-performance British jets are drawing fans to a new airshow on the circuit.

BY WILLIAM GARVEY

PHOTOGRAPHS BY MAX DERETA



The place was familiar immediately. The broad expanses of macadam. The gaggle of bright Pittses, hulking warbirds, and fragile ultralights in the center. Thousands of people, all in T-shirts and ball caps and sunglasses, slurping soda and pointing and gawking and standing in queues to inspect parked aircraft and hangar displays. Rock music and DJ chatter blaring from loudspeakers, the sun baking everything to bubbling. And permeating the scene, the odor of kerosene and the whine of turbine engines.

Yup, another airshow. But not quite like any I'd ever attended.

First there was the razor wire. Three feet high and bristling with blades, it snaked along the ramps and taxiways like a huge, evil Slinky, guarding the airplanes from the gawkers. Further ensuring the separation was an unsmiling young man in a dusty blue uniform, a machine gun cradled in his arm. Were the crowds to suddenly riot, hurdle the wire, overwhelm the soldier, and make a mad rush for, say, a Pegasus trike or Pilatus trainer, the armored vehicles scattered about could put things to order quickly. There was no question the military was in charge here (it *was* their property, after all).

Mike Beachy Head is the world's only civilian rated to fly the Lightning, Buccaneer, and Hunter (opposite, front to back).

Over 100,000 people attended Cape Town's 1999 show.

Then there was the food: Amid the omnipresent Coke and candy concessions were booths hawking *vetkoek*, *rootie*, and *samoosas*.

Finally, there was the odd date. It was summer, of course, but the calendar said that it was October 30.

Clearly, I was a long way from Oshkosh—actually, 78 degrees of latitude, eight time zones, and about 8,600 miles away—and happily so. For, with all due respect to Wisconsin's airplane Mecca, there are few places more naturally beautiful than Cape Town. A sun-soaked metropolis at Africa's southern tip, the city marks the merging of the chilled South Atlantic with the warmer Indian Ocean. Famous for its magnificent Table Mountain, excellent wines, snazzy waterfront, and rich sea life, Cape Town is a

magnet for European tourists, particularly during the winter months.

These days, some South African entrepreneurs are working to expand the city's attractions, and the show at the Ysterplaat Air Force Base, now in its second year, is a major component of that expansion.

As I wandered through the crowds, I ran into a compact, middle-aged fellow wearing a black flightsuit and drawing pensively on a little cigar. This was Mike Beachy Head, one of the key figures involved in the 1999 show. The event was sponsored by the South African Air Force Museum, which is located at the base, and a Beachy Head enterprise called Thunder City.

(Since everyone asks, here is the story behind the peculiar surname: Beachy Head is descended from 18th century French aristocrats named Rhenard. When the Revolution erupted, M. and Mme. Rhenard told their governess to board a ship and escape across the English Channel with their two young sons. They advised that once safely landed, the boys should be renamed, after the place of their deliverance. As it happened, the nanny and her charges landed at the East Sussex town of Beachy Head. Since he didn't end up Mike St. Mary's Bay, he doesn't complain.)

Beachy Head is an entrepreneur of the first order, involved in everything from an international student employment company to inboard/outboard engine design. One of his last major business successes was turning around a failing overnight air cargo operation, which he subsequently sold. During that undertaking he became interested in flying, and in 1992 he earned his private pilot's license and his multi-engine rating simultaneously. Keen for aerobatics, he bought a homebuilt Stolp Starduster II open-cockpit biplane. Soon he replaced that with a 300-horsepower Zlin 50. Eventually, that too was not enough.

Several years ago, his freight company's business agent gave him a call. The agent was in London, attending an auction at Sotheby's. Knowing of Beachy Head's interest in high-performance aerobatics, he asked if he should bid on a Hawker Hunter. "I didn't even know what a Hunter looked like," Beachy Head recalls. But he was impressed by the catalog description of the early British jet fighter, and decided, *I'll take a hack at it.*

As we spoke that Saturday in Cape Town, he turned and look skyward, appraising his shiny black Hunter as it streaked down the flightline, then pulled up to the vertical. Fans often describe the Hunter as "graceful," "elegant," even "beautiful." "Lucrative" is an equally appropriate adjective, for the Hawker turned out to be one of Britain's most popular exports, having been sold to about 20 countries. Its military service includes combat in Pakistan and India. It was the Royal Air Force's first

The Lightning's wheels have to be skinny in order to fold up into the thin outboard section of the wing. On average, Lightnings go through a set of tires every seven landings, though in a crosswind, a single landing is enough to wear a set out.

The Buccaneer S2b (top), once a low-altitude strike craft, pulled about five Gs on this flight, says pilot Beachy Head.

The vigilant military presence (opposite, top) didn't inhibit the crowd much (above).

transonic fighter, and in 1953 it reached 738 mph, a world record. Various versions specialized in interception, ground attack, and reconnaissance, and thus the Hawker has been characterized as the first genuinely multi-role combat jet.

An hour or so later, another black jet, this one a Blackburn Buccaneer, screamed to center stage. A beast of a high-speed strike fighter, the Buccaneer had been designed in the early 1950s for the Royal Navy to use for low-altitude attacks on warships. When Britain retired its carriers in the 1960s, the Royal Air Force took over the Buccaneers, using them for maritime strike missions in Beirut and the Gulf war, during which they both identified bomb targets and dropped bombs themselves. The Buc roaring past us now was the only one in the world still flying. At the controls was its owner, Mike Beachy Head.

The show continued with, among other things, a ghostly appearance by a single Spitfire, lovely aerobatics by a squad of South African air force Pilatus PC-7 Mark II trainers, an energetic performance by a team flying Pittses, an anti-terrorist demo that briefly set the airport's veld aflame, and even a flyby by a DC-4.

Between acts, I made my way to the VIP tent, taking sustenance in the form of dainty egg-tomato-and-cheese sandwiches and an icy glass of dry cider. Outside the seating area I found the VIPs themselves—dapper men in blazers with crests, smiling women in bright sundresses and halters, officers in crisp uniforms, and ultra-cool flyboys in flightsuits of various colors.

I strolled on among the hangars, which were jammed with a wide variety of exhibitors and activities, exemplifying the many cultures that have converged in the

Cape over the centuries. Located 25 miles north of the Cape of Good Hope, the area was first settled by Europeans in the 1650s, when the Dutch East India Company set up a station to supply its merchant ships bound for India and beyond. After that, the place began bringing sailors and settlers—some arriving by choice, others not—from near and far.

The food at the show reflected all that variety: *vetkoek*—a bread pocket with some sort of filling, *rootie*—an Indian pancake with mutton or curry, *samoosas*—triangles of fried mince. One stand sold little English pork pies, baked to perfection by a catering concern called the Delisha Sisters. Another sign advertised something called *biltong*. I asked a passing air force officer to translate. He waved the beef jerky he was chewing; "It's this," he said. And one food stopped me cold: the option of "monkey gland sauce" for my hamburger. Upon seeing my distress, a young woman reflected momentarily, then began to laugh. "It's ketchup with chutney and Worcestershire," she explained.

More surprises awaited me. The Ysterplaat show included an assortment of road machinery: a World War II Harley, a grand vintage auto called a Hupmobile, and a *Bullitt*-ready Mustang GT350, among others. It was a dazzling collection, and it struck me as decidely, well, un-African. (One pretty girl with a tattoo on her midriff set me straight, remarking, "People think that because we're in Africa, we're unsophisticated." Then she began punching buttons on her tiny cell phone. In the course of a few days, I became convinced that there are more cell phones per capita in Cape Town than in Hollywood.)

More proof of South Africa's sophistication appeared at a booth for the country's Association of Virtual Aviation (www.ava.org.za). Nearby was a South African air force recruiting set-up, which for some reason included a formal dining table with candelabra. The 22 Squadron, the search-and-rescue group that is stationed at Ysterplaat, showed off an example of its Oryxes (license-built Super Puma helicopters). Nosing out of one of the hangars was a Dakota—"C-47" to Americans—fitted with a pair of Pratt & Whitney PT-6 turboprop engines. (For more on such conversions, see "High Mileage," p. 30.) Some two dozen of the ancient Douglas transports still serve South Africa's air force. In fact, the first airplane to fly at the show was one of those C-47TPs, which proceeded to drop paratroops, much to the delight of the throng.

Unlikely as it was to hear a turbine whine emanating from a DC-3, the sound that followed was even more distinctive: the thrumming "Griffon growl." A unique sound produced by four Rolls-Royce Griffon engines turning counter-rotating props, the 48-cylinder growl was the signature of the Avro Shackleton, a patrol aircraft operated by the South African air force until 1984 and the Ysterplaat museum's pride and joy. This one was the last airworthy example; just 120 flight hours remained before the Shackleton's spar would need replacement—an undertaking considered prohibitively expensive. What the crowd was hearing was the end of an era. A haunting sound.

The attraction that probably pulled in the most visitors, who came from as far as England, Eastern Europe, and the United States, arrived thunderously from the northwest. It was another one of Beachy Head's all-black jets. This muscled banshee was once—and for many it remains—the pride of British military aviation: the English Electric Lightning.

Although little known in America, the British interceptor so utterly outperforms the World War II airplane of the same name that the P-38 could be renamed the Lockheed Languid. A few of the Brit's numbers explain why: max speed, Mach 2.1 (it's the Royal Air Force's only all-British fighter capable of Mach 2-plus flight); initial rate of climb, 50,000 feet per minute; power

The South African air force used the airshow to display examples of it's aircraft (below)

Top: The right-seat officer of the Buccaneer handles communications and conducts various team checks.

Above: Airshow food, South Africa-style—scary-sounding but delicious.

plant, twin Rolls-Royce Avon 301s rated at 16,300 pounds of thrust each. In service with the Royal Air Force in Germany, Cyprus, and Singapore between 1960 and 1988, this screamer of a cold warrior was designed so that the pilot could shoot air-to-air missiles via a steering dot on the radar display and still control the aircraft. During the cold war, the Lightning was used to intercept Soviet aircraft overflying the North Sea (the one performing at Ysterplaat had in fact intercepted a Tupolev Tu-95 Bear there).

In the United Kingdom, the Lightning's feats have earned the aircraft legendary status. Fans recount a 1984 NATO exercise in which a Lightning intercepted a U-2 reconnaissance jet at 66,000 feet—an altitude at which the U-2 had always been thought safe from interception. And the following year, during a British Airways trial over the North Sea, a Lightning proved it could overtake the Concorde supersonic transport at 57,000 feet.

There's one more number relevant to the display that day at Ysterplaat: Total number of flyable Lightnings in the world—one. This Lightning had served in the Royal Air Force from 1965 through 1988, when it was decommissioned; it then passed through several private owners. The British government declared it would not permit any civilian-owned Lightning to fly there. But the South African civil aviation authorities took a different view: They will consider a civilian registration to fly such an airplane if the craft meets scrupulous airworthiness and maintenance criteria and the pilot has been trained to the highest standards.

Beachy Head bought the Lightning in 1996, had it dismantled and shipped to Cape Town, then had it reassembled—rebuilt, really. Meanwhile, he spent six months at British Aerospace in England training to fly the aircraft. He first took it aloft in March 1999 with test pilot Keith Hartley of British Aerospace (which had assumed support for the Lightning). The performance at Ysterplaat was the jet's first public appearance under Beachy Head's ownership.

Computer programmer David Griffiths was one of a handful of Brits who had spent around $1,500 and traveled the length of Africa to see a Lightning fly again. The sight of that icon, as well as the show's other aircraft, kept him and his similarly impassioned companions chained to their seats. Despite the sun's intensity, they remained there, necks craned, from the show's 8 a.m. start to the finish seven and a half hours later. At the close they were sunburned and satisfied. Griffiths' assessment: "Although not the largest, it rates as the most amazing of hundreds of airshows I've attended." The event had been "beyond our wildest dreams," he said—an opinion loudly endorsed by his fellow Brits. They all said they planned to return.

And that is precisely Mike Beachy Head's goal. A concept began forming in his mind the first time he flew the Buccaneer in Cape Town. He had bought the craft because it was configured as a tanker, and he intended to use it only to refuel the Lightning. He was taxiing the Buccaneer to the active runway at Cape Town International when he noticed that cars were parked all along the field and people were standing on their roofs. At first he figured that the Concorde or some celebrity was arriving, but when none showed he realized it was the Buc that was the cause of the commotion. "I thought I ought to be charging them for this entertainment," he recalls. He began giving the idea serious consideration.

The initial result was pretty straightforward: Sell rides. Today you can contact Beachy Head or Incredible Adventures, his U.S. agent, to book a ride aboard the Lightning, Buc, Hunter, or little BAC Strikemaster. Beachy Head has been the principal jet tour guide, though Keith Hartley and other BAe pilots have taken some of the flights.

But before you sign up, you might need to extend your credit card limit. A ride in the Hunter will cost you $3,000 an hour; the Buc goes for $8,000, and the Lightning a thousand more.

Simon Wells knows the cost. A power plant engineer from Greatstone, England, he saved for the better part of a year to ride the Lightning. But after arriving in Cape Town, the 28-year-old bachelor had serious misgivings about his investment. "I thought, *This is a bit over the top*—that I'd been ripped off," he said. But that was before he departed Cape Town International with his nose pointed 70 degrees skyward, afterburners alight, and, once level, boring straight through the cerulean sky at a satisfyingly shocking Mach 1.4.

"Excellent!" the new Mach-buster reported. And despite a fare of $100 ($160) per minute, he said, "I would do it again."

Of course, not many are as able or willing as Wells to ride one of the black rockets, so Beachy Head and Alan Ramsay, publisher of *Car* and other slick South African magazines, have come up with a lollapalooza of a scheme to pull in the rest. Thunder City is to be, among other things, an entertainment center, based at Cape Town International, filled with airplanes and cars of every description, from every corner of the world. In addition to watching videos, playing with touch screens, and *ooh*ing at fighters on display, visitors will be able to get blasted in an ejection seat, race a dragster, pull Gs in a dogfighting roller coaster, and make muddy doughnuts in real four-wheelers. And at the center of it all will be Beachy Head's fleet of jets: the Buc, the Strikemaster, and four Lightnings—that's right, four; he's so pleased with the aircraft he's gone back to England for another three, all of which he hopes to return to flying condition in the near future.

"Our mission is to make Cape Town the jet Oshkosh of the world," Beachy Head says. "This is where all the jet junkies will come."

He may be right. Bookings for rides in his jets spiked after their appearance at the Ysterplaat show. And at the next show, scheduled for October 27, 2000, there should be two Lightnings flying.

If you attend, remember two things: First, bring plenty of sunblock, and second, if a pretty girl offers, say yes to the monkey gland sauce.

At this hangar in the Cape Town International Airport, Beachy Head's restorers bring classic jets back to life. If all goes as planned, more Lightnings will be bolting forth at future Cape Town shows.

STARZ in the HOOD

There are more stars in our celestial backyard than we once thought.

by Michael Milstein

One day while in junior high school in the late 1960s, Dana Backman strayed into the adult section of his local library, wondering what sort of books adults read that weren't available on the other side of the building. One of them was *Habitable Planets for Man,* written by astronomer Stephen Dole. A pioneering report commissioned by the RAND Corporation years before the first moonshot, Dole's book assessed the possibility that planets suitable for human colonization were circling stars other than our sun.

"I was really just a science fiction fan at that point, but this was real stuff," Backman recalls of his teenage discovery. "I was fascinated. I ate it up. I memorized it."

Based on the ages and masses of stars in the galaxy and the many criteria necessary for habitable planets—water, an atmosphere with oxygen, light, certain chemicals, some gravity but not too much—the book estimated that up to 10 stars within 20 light-years of Earth may have human-friendly planets orbiting them. Especially striking to Backman was the suggestion that planet-bearing stars may be relatively unimpressive to look at. Indeed, an intelligent being on a planet circling the nearest star, about four light-years away from us, would regard our sun as pretty run-of-the-mill.

Later, while studying astronomy in college and graduate school, Backman was puzzled by the fact that most other researchers showed little interest in our stellar neighbors, preferring instead to look toward the far edges of the universe. When he talked excitedly about the possibility of planets beyond our solar system, other scientists looked at him as if he were reporting a fleet of UFOs. Still, he wondered to himself what astronomers must be missing.

Now he thinks he knows: Stars. Lots of 'em.

Today, Backman is one of the principal scientists behind a new NASA and National Science Foundation research initiative called the Nearby Stars Project, which seeks to fill a gaping hole in our knowledge of our own celestial neighborhood by cataloging stars within 25 parsecs, or about 80 light-years, of the sun. Rough estimates suggest that astronomers have measured the distances to only about half the stars within that range. The rest have yet to be recognized as nearby objects. A good number of them are perfectly visible, may even have a name, yet they remain anonymous, hidden in the vast crowd of more distant stars like an astronomer's version of "Where's Waldo?"

Ironically, nearby stars are the best places to look for planets beyond our solar system—the kind of planets that once earned Backman funny looks from his colleagues but which now make headlines around the world. The stars we should know best, it turns out, we hardly know at all.

"To be told that half the stars in our neighborhood are basically missing is something of a shock," says Harley Thronson, a senior program scientist at NASA headquarters in Washington, D.C., who initially fostered the Nearby Stars Project, also called NStars. It's also "a big handicap when you're planning multimillion-dollar missions to look for planets around such stars. It means you don't know where to look."

Cataloging stars is not a new idea, but the NStars project will compile computerized dossiers packed with information never before included in conventional star catalogs—details such as a star's age and the amount of dust swirling around it—that bear on the ability to support Earth-like planets. If such details are lacking, the project will sponsor research to nail them down. "This isn't a matter of just punching numbers into a computer," says Backman. "It's a matter of aggressively identifying what we need to know but don't know, and going after it."

Researchers eager to test the limits of bigger and better telescopes have routinely skipped past the ho-hum objects close to home and focused instead on the biggest, hottest, and most distant attractions in the universe. Neutron stars, supernovae, and other stellar exotica make up only a small fraction of the population of stars, but for several decades they've been the most attractive objects to study, according to Backman, who today is a professor of astronomy at Franklin and Marshall College in Lancaster, Pennsylvania, with a dual appointment at NASA's Ames Research Center in California.

"Astronomers are just big kids—they like things that blow up, that shoot off sparklers or collide," says Thronson. "But the majority of everything falls into the range of what we call normal." That neglected category actually includes stars with different sizes, shapes, and histories, he adds. "Really the greatest variety lies in normalcy, because 'normal' stars are by far the most abundant, and probably the most likely to have planets like ours. 'Are we alone?'—a fundamental question—will probably be answered in these stars."

Our nearest stellar neighbor, Proxima Centauri, shines brightly in this Hubble Space Telescope photo. Astronomers deliberately overexposed the image, hoping to see the dim light of possible planets. None were found.

JACK SCHMIDLING

Barnard's Star, in the constellation Ophiuchus, doesn't stand out in the night sky. But at 5.9 light-years away, it's the second nearest star to our sun.

Indeed, many of the 30 or so planets discovered beyond our solar system orbit commonplace stars. Encouraged by the growing list of extrasolar planets detected from ground-based telescopes, NASA plans to launch a series of space-based observatories, beginning with the Space Interferometry Mission in 2005, with the ultimate goal of finding Earth-like planets that have the potential to harbor life. The best chance for success lies in nearby stars, because the resolution of the images and spectral data will be higher. But which nearby stars?

"There's a list of maybe 10 things, a kind of rap sheet for these stars that you need to fill out," says Chas Beichman, chief scientist for NASA's Origins program at the Jet Propulsion Laboratory in Pasadena, California. For example, thick dust in other solar systems could obscure the vision of the Terrestrial Planet Finder, a more powerful telescope that's slated to follow the interferometry mission into space around 2011. So it wouldn't make sense to waste valuable observing time on dusty stars, even though these may be the incubators of future solar systems. It won't do much good in general to look at very young stars, since it takes a long time for swirling dust to turn into planets that are even remotely Earth-like. It would probably be useful to target stars with high concentrations of heavy metals, since those elements seem to contribute to planet formation. But they have to be close—within the 50-light-year range that the Terrestrial Planet Finder can examine in detail. All in all, the 200 to 300 star systems to be investigated by that advanced instrument will have to meet a stiff list of criteria.

So far, though, the rap sheets are distressingly blank. When Beichman, Thronson, Backman, and their colleagues convened a meeting in 1997 to discuss dust in other solar systems, it quickly became obvious that there was hardly any information on the subject. In fact, there was hardly any information on neighboring stars, period—and nowhere near enough to start picking suitable targets for the Terrestrial Planet Finder.

Today's ground-based planet hunters know the problem all too well. "Right now we sift through an incredible amount of information looking for candidate stars, because we know so little about these stars," says Debra Fischer, an astronomer at the University of California at Berkeley and member of the prolific planet-finding team that includes Geoffrey Marcy of San Francisco State University and Paul Butler of the Carnegie Institution of Washington. The list of candidates includes a lot of bright stars, because stars that appear bright in the sky are more likely to be close. But that general rule doesn't always hold. For example, the brightest and third brightest stars in the sky—Sirius and Alpha Centauri—are both less than 10 light-years away, just around the corner in interstellar terms. But the second brightest star, Canopus, is 74 light-years distant. And giant Betelgeuse, number 10 on the list, is a whopping 500 or so light-years away.

Although most easily visible stars have been named or numbered and we know their coordinates in the sky, in many cases we don't know how far away they are. That third dimension, distance, is critical for planet-hunting. It's also by far the most difficult variable to nail down.

The most common means of finding the distance to a star is to determine its parallax, which is an angular measure of its apparent movement against other, more distant objects in the background (see diagram, p. 52). The closer a star is to Earth, the greater its parallax. The same principle holds when driving on a multi-lane expressway: Cars in the next lane appear to be moving faster against the surrounding landscape than do cars in the far lanes. Astronomers repeatedly photograph a target star, and by measuring its gradual movement against the background (it usually takes at least two years to get a good parallax), they can use trigonometry to calculate its distance from Earth. It isn't the most glamorous work in science, which probably explains why parallax data is simply lacking for most stars, particularly in the southern hemisphere, where historically there haven't been as many astronomers.

The lack of good distance estimates for most stars has long nagged Todd Henry, an astronomer at Johns Hopkins University in Baltimore and the deputy project scientist for Backman's small NStars research effort at Ames, which, confusingly, has the same name as the larger NASA-NSF program just getting under way. Henry's first job, funded by the Search for Extraterrestrial Intelligence back in 1991 when NASA was still running that program, was to identify stars that might warrant further scrutiny in a search for radio signals from alien civilizations. Henry worked off a list of the 100 stars known to be closest to Earth, but soon found himself puzzling over four objects that weren't on the list, even though they were quite bright.

That curiosity led Henry and six other researchers to cre-

ate an informal group they called the Research Consortium on Nearby Stars, or RECONS, to investigate unidentified shining objects. In 1995 the group got time at a complex of mountaintop observatories in Chile, where they measured the brightness of Henry's four objects at different wavelengths. The photometry data revealed that three of the objects were in fact stellar giants, very bright but also very distant. The fourth star, which had seemed the most promising from the beginning, turned out to be a more common star known as a red dwarf, but its distance from Earth was not recorded in the catalogs.

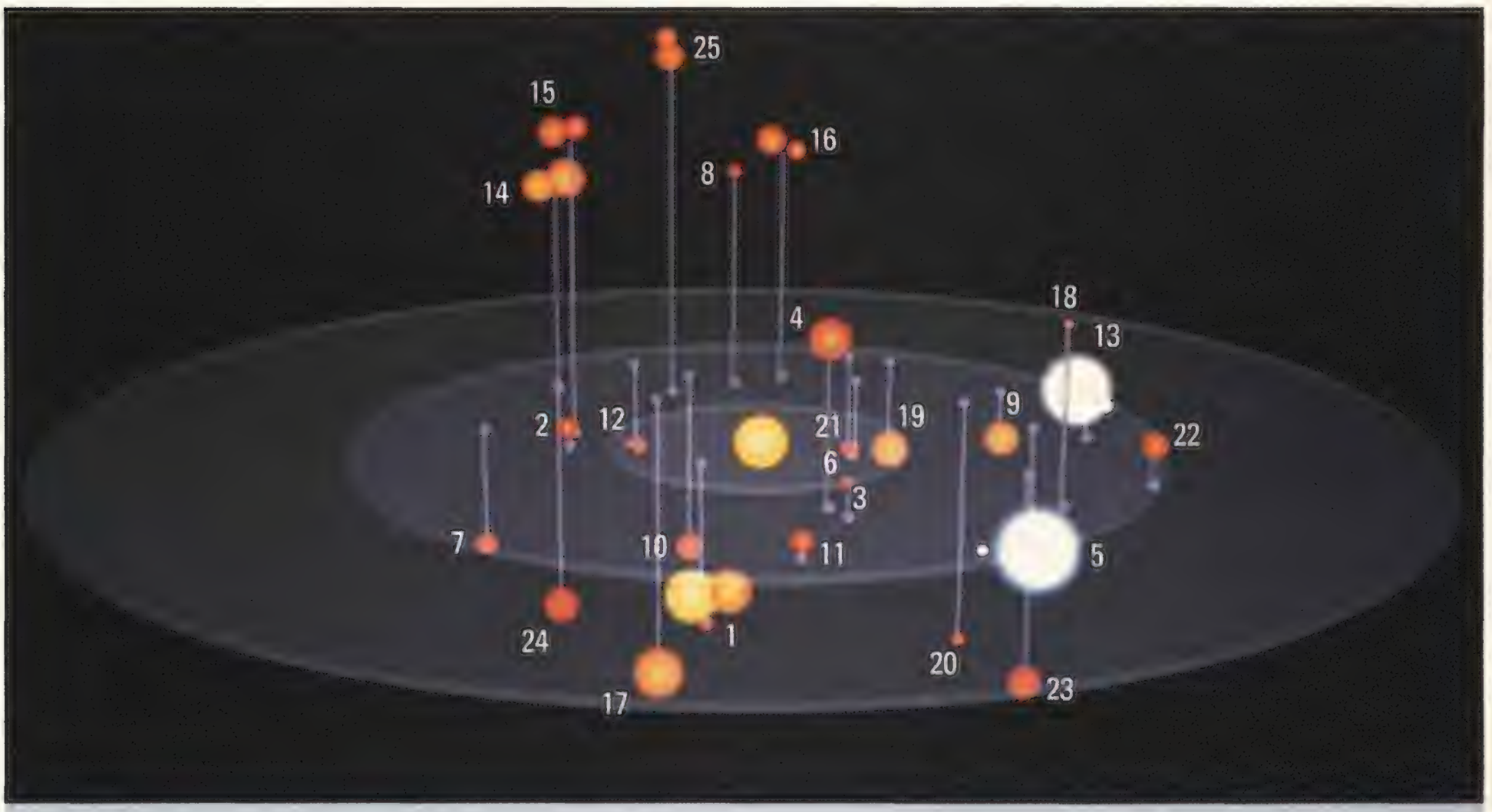
As it happened, Henry lucked out. Astronomer Philip Ianna of the University of Virginia had already collected images of this particular star from 1976 through 1990, but hadn't yet found time to extract parallax data and crunch the numbers to come up with its distance from Earth.

"I said, 'Phil, do the numbers now!' " Henry recalls. It took only a few weeks to determine that the star, which goes by the unassuming tag GJ1061, was just 12 light-years away, making it the 20th nearest star—scarcely three times farther than our closest neighbor, the Alpha Centauri system, which includes the stars Alpha Centauri A, Alpha Centauri B, and, closest of all, Proxima Centauri.

"I'll let you in on a secret," Henry says. "We have better numbers now, and they show that it's actually even closer. A few years ago, no one knew it was there." The team gave the star another, newer name: RECONS 1.

The discovery led Henry to some simple calculations. Within five parsecs, or about 100 trillion miles, we know of 60 stars and one planet beside our own solar system. Let's say this represents most, if not all, of the objects actually out there. Simply assuming that the density of stars remains the same out to 10 parsecs, there should be roughly 500 stars within that volume of space. Yet astronomers have counted only about 315.

Within 20 parsecs, there should be about 4,000 stars. "We



In this three-dimensional view looking down on the extended plane of Earth's equator, star positions are projected onto the plane as purple dots. Stars of the same spectral class as the sun are yellow, while hotter, more luminous stars are blue or white, and cooler stars are red. Star names are followed by their distance from us in light-years.

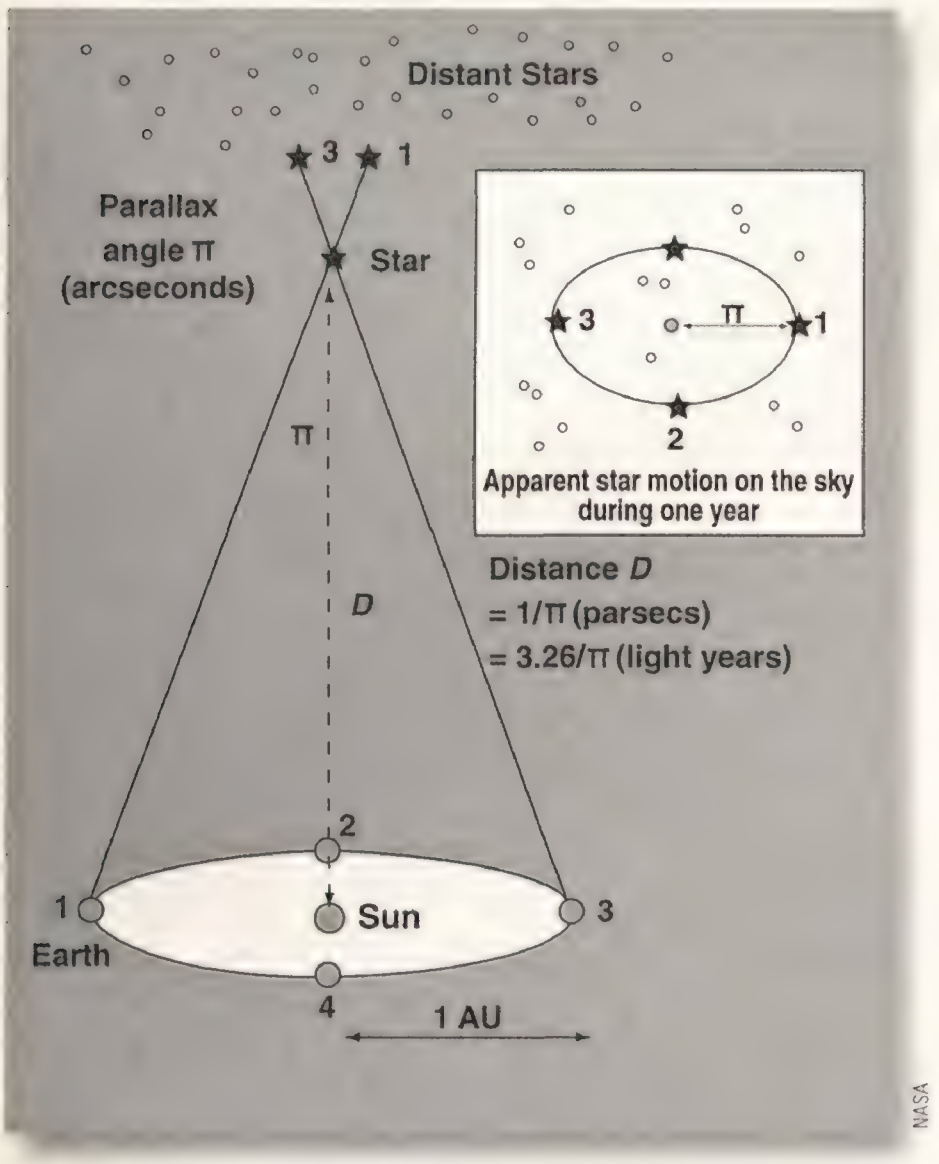
The 25 Nearest Star Systems

1. Alpha Centauri—4.3
2. Barnard's Star—5.9
3. Wolf 359—7.7
4. Lalande 21185—8.2
5. Sirius—8.5
6. UVCeti—8.7
7. Ross 154—9.6
8. Ross 248—10.3
9. Epsilon Eridani—10.5
10. Lacaille 9352—10.7
11. Ross 128—10.9
12. EZAquarii—11.2
13. Procyon—11.3
14. 61 Cygni—11.3
15. GL 725—11.5
16. Groombridge 34—11.6
17. Epsilon Indi—11.8
18. DXCancri—11.8
19. Tau Ceti—11.9
20. RECONS 1—11.9
21. YZCeti—12.1
22. Luyten's Star—12.3
23. Kapteyn's Star—12.7
24. AXMicroscopium—12.8
25. Kruger 60—13.1

ALFRED KAMAJIAN/ TODD HENRY/ RECONS

know of about half that," Henry says. "I like to compare it to a baseball field, where you have quite a few infielders but far fewer in the outfield. In fact, the density of players in the outfield of space should be about the same as the infield. We just haven't located them yet. People ask me, 'Why don't we know where the rest of them are?' The simple answer is 'Because there are a lot of dots in the sky.' It takes time to map everything out, and we just haven't been at it that long."

Astronomers also don't always share information as effectively as they could, so it may be that parallax data for other nearby stars actually will be found in Ianna's or some other researcher's files. Or it could be that different astronomers have pieces of the puzzle that, once put together, could reveal stars much closer than anyone thought. So Backman's team will build an unprecedented database from as much information as they can round up from the existing scientific literature, and make it available to astronomers and the general public over the Internet. The team's search for relevant information has already turned up other candidate nearby stars. An expected influx of additional data from new sky mapping projects such as the Sloan Digital Sky Survey—which aims to chart more than a hundred million celestial objects, including stars, galaxies, and quasars—should yield even more discoveries.



NASA

The tried-and-true method of measuring trigonometric parallax is still the best way to determine stellar distances with confidence. Astronomers mark a star's position against the stellar background, then mark it again six months later when Earth is half an orbit (187 million miles) away from its original location. Nearby stars will appear to have moved against the background. Barnard's Star, for example, "moves" about 10 arc-seconds a year.

The second element of NStars calls for additional research—using telescopes around the world to identify "new" nearby stars based on their parallaxes and to learn more about those that are already known. University of Texas astronomer Fritz Benedict, for instance, plans to seek funding to examine about 500 stars for signs that they are binary, or double stars; he expects that around 20 percent will be. Researchers could then exclude those stars from the list of candidates for planet hunting, because stable planets are unlikely to form in binary systems.

The research will have a wider purpose than just adding to the roster of nearby stars, says Benedict. "It's not only filling in the blanks on our star catalogs, but also filling in our understanding of the way solar systems might work."

The idea of NStars had so much appeal that when NASA launched the project last year, the National Science Foundation quickly offered to contribute half the initial funding of $1.2 million. By October, the funding agencies had received around 80 proposals, twice as many as they had expected, which led them to try to scrounge up more money.

Backman and Henry sound like kids on Christmas Eve when they talk about the wonders NStars should soon reveal. "I've been waiting for this for 10 years," beams Henry. "I'm sure we will find new things, all kinds of crazy things. The nearest star, Proxima Centauri, may not be the nearest star. It's really hard to guess what we're going to find."

But he hazards a guess anyway. Henry figures that most of the 2,000 or so uncounted stars within 25 parsecs of us will turn out to be faint red dwarfs about the size of Jupiter. Stellar censuses suggest that these dim objects, which are far fainter than the sun, dominate the star population, and our own neighborhood should be no exception. Although such stars shine too feebly to offer much hope of finding planets suitable for life, Berkeley's Debra Fischer and her planet-hunting colleagues have already found one planet revolving about a red dwarf. They believe that most red dwarfs—in fact most stars—sport planets of some type.

"I think they all have planets," Fischer says. "The mounting evidence we have is basically that if we can find planets around a star—if our technology is good enough to see them—then we do. It really looks like planets are manufactured very efficiently around stars."

There's one last reason, of course, to tote up a list of nearby stars, and to find out if they have habitable planets. If we ever learn how to travel the immense distances of interstellar space, we'll want to visit the closest solar systems first.

Sadly, though, Fritz Benedict already appears to have ruled out the first stop in this cosmic voyage. After years of observing, Benedict found no evidence of planets around Proxima Centauri, the closest member of the Alpha Centauri triad. It was perhaps no surprise, given that the star doesn't seem to be rich in the heavy metals that help planets glom together. Still, it's disappointing. But as Todd Henry will happily tell you, there are plenty of other stars in the sky. And they may be closer than you think.

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"We will make our thrust here," the colonel says. "The rocket launchers will be along the ridges. We will release the gas from the warehouse by the field—here. They will never think it is coming from there because the lights will be on. They will expect the gas to come from the water tower. All units must be in position before dawn. We will take them completely by surprise. Aah, these flies!"

He slaps his hand down so hard that coffee splashes from his cup, then inspects his palm with a satisfied expression before wiping it on his thigh.

Six miles away in a subterranean bunker a video monitor goes blank. A bespectacled lieutenant in a camouflage shirt sighs and gets up from her chair. She stretches, then crosses the room to an open door. "Frank," she says, leaning in, "can you send some more flies?"

Microspies

Can tiny aircraft deliver the big picture?

by Peter Garrison *Illustrations by John MacNeill*

In his cluttered office in the Los Angeles suburb of Simi, Matt Keennon tosses a diaphanous creature into the air. Tremulous but purposeful, it flaps its way across the room, where waiting hands catch it. Cradled in them, it flutters a moment longer, then subsides when its captor's fingers—huge, clumsy things beside the ethereal flier—click off its master switch.

The little creature is called the Microbat. It was built at the California Institute of Technology's Micromachining Laboratory by a team of graduate students overseen by Yu-Chong Tai. The effort also involved AeroVironment, which is headed by Paul MacCready, a multi-disciplinary engineer famous for, among other things, the Gossamer series of human-powered aircraft. The youthful Keennon is AeroVironment's project manager for micro air vehicles (MAVs), a new class of aircraft being funded by the Defense Advanced Research Projects Agency (DARPA). The toys in this game are small, but the players are big.

The Microbat's thorax and wing-flapping mechanism consist of tiny sticks of carbon fiber. Its wings are gossamer plastic webs supported by a network of stiffeners that were not built up of separate components but etched from single sheets of titanium alloy by the same photolithography techniques that are used for the mass production of computer microcircuits. The Microbat carries no payload, and it serves no purpose other than to demonstrate the feasibility of a small electric ornithopter that can operate only at low speeds and indoors, where a drop of rain or a puff of wind will not immediately destroy it. More important, it demonstrates the possibility of building parts of flight vehicle structures by chemical micro-machining. Both demonstrations are prophetic.

Slow-moving, moth-like airplanes (as well as crawling robotic cockroaches and other sci-fi stuff) are where reconnaissance seems to be headed now. So-called MEMS (micro-electromechanical systems) manufacturing techniques, derived from the tools of computer chip manufacture, will get it there.

DARPA's involvement with toy-size airplanes began at a workshop entitled "Future Technology-Driven Revolutions in Military Operations," conducted at the RAND Corporation in Santa Monica, California, in 1992. Bruno Augenstein, a RAND scientist, chaired a panel discussion on power supplies for "mobile microrobots," then a completely hypothetical class of military vehicle. Despite initial skepticism, the idea that an airplane that would fit in the palm of your hand might be a useful reconnaissance device gradually took hold.

In 1995 DARPA put out a specification for a small camera-carrying aircraft. Six inches—an arbitrary value, but one that has turned out to make practical sense—was the basic constraint: The entire aircraft had to fit within a six-inch sphere.

Matt Keennon flies the remotely operated Black Widow using its briefcase-size ground system, which combines a compressed-air launcher, an antenna, and a hooded viewer slung around Keennon's neck (below).

CHAD SLATTERY (3)/AEROPIX.COM

The wing stiffeners of the Microbat (above) are actually etched from sheets of titanium. The Microbat is an ornithopter: It flaps its wings to fly. Belly up, the remotely guided Black Widow reveals its innards. The micro air vehicle (MAV) is about twice the size of the Dicronorhina micans, *a beetle measuring three inches, pincer to pincer (below).*

DARPA also specified a typical mission. The midget spyplane would fly one kilometer, just over half a mile, to a target; loiter there for half an hour in turbulent winds of up to 25 mph, perhaps maneuvering among obstacles such as buildings while repeatedly climbing to 350 feet and descending again; then return to its base. It had to be quiet and inconspicuous, its launching and control system had to be easily portable and operable by an unskilled person, and the whole system had to be both robust and cheap.

In 1997 DARPA gave grants totaling several million dollars to several organizations to develop MAVs; AeroVironment, which had already begun attacking the problem on its own, was one of them. The company's Simi Valley facility has produced a number of flying models, most of them of roughly circular planform, six inches in diameter, and powered by a single tractor propeller spinning at 20,000 rpm.

The most successful of AeroVironment's models, nicknamed Black Widow, has remained aloft for more than 20 minutes flying at 35 mph. The ground operator launches it by compressed air from a telescoping rail, then controls it in flight by radio, like a model airplane—which, after all, it is. Unlike the typical radio-controlled flier, how-

ever, the Black Widow's operator watches not the airplane itself, which is a mere speck darting in the sky, but the video picture sent back by its tiny television camera. The whole apparatus—airplane plus launch and control mechanisms—fits in a briefcase.

Fortuitously, Keennon says, various pieces of "COTS"—commercial off-the-shelf—hardware are available in the right size to fit on a six-inch flying disk. Flight controls, for example, are operated by tiny Swiss-made electric motors an eighth of an inch in diameter and 0.01 ounce in weight. The airplane's "eye," also an inexpensive item, is a 510- by 492-pixel color array like the ones used in home video cameras but stripped down to the size of a bean and the weight of 0.05 ounce.

AeroVironment's current MAVs are skittish creatures, with high roll rates and low natural stability. They require skilled radio control operators. The next step in the program, which the company is currently pursuing with its own funds, independent of DARPA's support, is to add electronic gyroscopes and autopilots that will keep the airplanes stable and upright. The operator would then need no special skill to fly one, and would be free to concentrate on the mission rather than on controlling the aircraft.

After adding stability, the next improvement will be GPS navigation, which would permit the MAV to fly a programmed mission without assistance from a human operator. The icing on the cake would be some kind of system using acoustic or optical sensing that would let it maneuver in an urban environment, avoiding obstacles on its own, just like a bird. That level of autonomy, however, is still far off.

The requirement that it send back usable video images puts an important lower limit on the size of a MAV, because each pixel in the imaging array must be considerably larger than the longest wavelength of visible light. This means that a video camera capable of sending back useful detail can't be much smaller than the one Keennon's team is now using. Another non-scalable item is the radio antenna. An antenna that fits within a six-inch space works efficiently only with short-wavelength, high-frequency radio waves. Unfortunately, high-frequency radio signals travel by line of sight—both antennas have to be able to "see" each other—and do not readily penetrate walls or travel around hills. A longer retractable trailing wire, however fine, would impose a severe drag penalty. Antenna size will also pose a problem for GPS reception, especially if future MAVs became significantly smaller than the current ones.

The peculiar configuration of AeroVironment's MAVs is the logical outcome of the six-inch size restraint. If you merely scaled a conventionally proportioned airplane down to a six-inch wingspan, its wings would have an area of only about .04 square foot. Flying at 30 mph—a higher speed would require too much power—such a wing could support only about three-quarters of an ounce at most, with no margin for maneuvering or gust response. But the weight of the entire aircraft, including powerplant and all the electronic and sensing equipment it is supposed to carry, would in reality be around two or three ounces.

It turns out that the best solution is simply to make the wing area as large as possible—essentially, to fill the entire six-inch DARPA circle with wing. This approach has other advantages as well: It provides a simple, stiff, voluminous structure with ample interior space for systems and payload. True, the circular planform lacks the characteristic usually associated with efficient airplanes: a fairly high aspect ratio. The most efficient airplanes have wings whose span from tip to tip is much greater than their chord—the distance from leading to trailing edges—and you don't see a lot of airliners with circular wings.

But for an airplane of this size or smaller, a low aspect ratio may not be a hindrance. The very wingtip vortices that produce drag on conventional airplanes help produce lift instead on small, short-span wings operating at low Reynolds numbers (see "Mr. Reynolds, We've Got Your Number," next page). In fact, recent research on insect flight suggests that the judicious use of tip and leading edge vortices keeps those notoriously small-winged bumblebees—the ones that, according to legend, myopic scientists have pronounced flightless—aloft. This is only one of the differences, fundamental to the creation of miniaturized aircraft, between full-scale and micro-scale aerodynamics. The behavior of air on micro-scale wings is only beginning to be understood.

Although most of the systems of a MAV are electronic and AeroVironment has concentrated on electrically powered airplanes, not everyone agrees that an electric motor is the best choice for a powerplant. Batteries have a low "power density"—that is, they pack little punch for their weight. (This is a problem for electric cars as well.) For some tasks, such as peering into upper-story windows or loitering inconspicuously, an aircraft that can hover is essential; at present, battery-powered electric motors don't have the power to hover for long.

Those traveling the all-electric route look to future improvements in batteries, motors, and propellers, as well as to further miniaturization, for increases in power-to-weight ratio and efficiency—the fraction of the available power that goes into useful work—of tiny power plants. But gram for gram, chemical fuels like gasoline are much more energetic than batteries, and even though extremely tiny internal combustion engines, unlike tiny electric motors, are not available off the shelf, several programs are taking the internal combustion route instead.

MLB Company of Palo Alto, California, has flown several designs powered by small Cox model airplane engines. One of them takes off vertically. Stephen Moore of MLB says that at this scale the power requirement for vertical takeoff and hovering is not terribly different from that for agile maneuvering. Given the tremendous energy content of chemical fuel, a multi-mode tail-sitter craft that can both fly and hover becomes an attractive possibility.

A startling solution to the power problem is in the offing at the Mas-

Mr. Reynolds, We've Got Your Number

Take a walk on the beach. Your feet sink deliciously into the warm sand. Now scale yourself down to the size of a flea on the same beach, and try to get on with your walk. Help! You're tripping and stumbling among knee-high boulders, and you hardly make any headway at all.

The same principle applies to airplanes moving in air. Air is really a granular substance, like sand, made of separate molecules a certain average distance apart, and with a certain "stickiness," or mutual friction. You can scale down the airplane, but you can't scale down the air. So the same airplane behaves differently at different scales, or, to put it anthropomorphically, air "feels" different to airplanes of different sizes.

The relationship between the size of an object and the feel of a fluid medium surrounding it is summed up—and has been for more than a century now—in a wonderfully powerful mathematical shorthand called the Reynolds number.

The discovery of Reynolds number, or RN as it is usually abbreviated, arose not from aerodynamics but from plumbing. The size of pipe needed to carry a certain flow, and the amount of pumping power required to overcome the resistance of a pipe over a given distance, are fundamental problems of hydraulic engineering. Efforts at experimental measurement had yielded baffling discontinuities and apparent contradictions. Fluid flow was a Jekyll-and-Hyde kind of phenomenon, swapping identities and behaviors for reasons that seemed to defy comprehension.

Osborne Reynolds (1842–1912) was a classic absent-minded professor. Irish born, a lifelong professor in engineering at the University of Manchester in England, he was known for sometimes drifting off in the middle of a lecture and working out the mathematics of his newest insight on the blackboard while bewildered students twiddled their thumbs. Reynolds was, however, an original scientific thinker with the practical instincts of an inventor. He did significant work in several areas, but his most lasting contribution was to the field of fluid mechanics.

The experimental apparatus that led to the discovery of Reynolds number can still be seen today in a gallery documenting his work at the University of Manchester. It consists of a horizontal glass pipe with a trumpet-like flared inlet. The pipe is immersed in a tank of water and vents to

the outside. Reynolds would open a valve to allow water to flow out through the glass pipe; at the same time, he allowed a small nozzle to inject a fine stream of dye into the pipe's inlet. Reynolds could control the speed of flow in the glass pipe and watch the behavior of the filament of dye running through it.

He observed the same phenomenon that one used to observe back when indoor smoking was permitted. Just as smoke would, in still air, rise several inches from a cigarette in a smooth stream and then abruptly burst into disorderly eddies, the dye stream would remain perfectly straight and coherent at first, then explode in turbulence and lose its identity in the larger stream.

Today we call the two types of flow Reynolds observed laminar and turbulent. In laminar flow (see "Go With the Flow," June/July 1995) the path of each small packet of fluid—a "packet" is an arbitrarily small volume, but much larger than a single molecule—is parallel to those of its neighbors. The flow resembles well-combed straight hair. In turbulent flow, on the other hand, small whorls and eddies develop in the overall flow, so that as they all travel downstream, each packet of fluid moves in a different direction from its neighbors. Reynolds discovered that whether flow in the pipe remained laminar or became turbulent depended on a simple arithmetical relationship of four factors: the diameter of the pipe, the speed of the flow, and the density and viscosity of the fluid.

Laminar flow has only half as much resistance as turbulent, so engineers try to maintain laminar flow over as much of an airplane's surface as possible in order to reduce drag. But the significance of Reynolds number goes well beyond simple drag reduction. Reynolds number is a "similarity parameter" that allows designers to account for scaling effects and for different regimes of operation.

Here is Reynolds' equation:

$$RN = VDr/m$$

Despite the Greek symbols rho (r) and mu (m), this is a very simple expression with very clear implications. V is speed, D is a dimension—in the case of wings, it is chord, the distance from the leading edge to the trailing edge—r is the density of the fluid, and m its viscosity. Once you pick your fluid it gets even simpler, since

r/m is a constant. Its value is about 6,400 in air at sea level, so to get the Reynolds number for ordinary airfoils flying at low altitude all you have to do is multiply the length of their chord in feet by their speed in feet per second, then multiply that result by 6,400.

Since you multiply by speed, density, and size but divide by viscosity, it follows that as the speed, density, or size increases, the Reynolds number increases, whereas as the viscosity increases, Reynolds number decreases. The fact that flows at similar Reynolds numbers behave similarly implies that, for example, a slow flow in a thin fluid behaves just like rapid flow in a thick (more viscous) one. Or a small object in a thin fluid is similar to a large object in a thick fluid. One of the convenient consequences of these relationships is that the Reynolds number of the keel of a sailboat, operating at low speed but in a relatively dense medium, is similar to that of an airplane wing traveling many times faster in air; so all the research done to create airfoils for airplanes applies equally well to sailboats.

The almost magical power of the Reynolds number leads us to the strangest conclusion of all: Air feels to a gnat, the way oil, or even honey, feels to us. So flying, when you're very tiny, isn't flying at all anymore. It's swimming.

The laws of flight are consequently different for very tiny fliers. The things that aerodynamicists normally strive to optimize—airfoils, wingspan, surface smoothness—cease to mean anything at very small scale. The wings of small living fliers may even cease to be continuous surfaces, and may be replaced by collections of hairs more like palm fronds than wings. The smoothly curving flows that generate lift on the large scale are replaced by swirling eddies; tiny insects paddle rather than soar. Up to now there has been little investigation of practical aerodynamics at very low Reynolds numbers, so it is not yet clear how an extremely tiny flying machine ought to be designed. But one thing is already obvious: A tiny air vehicle, whatever it is, will not be a shrunken copy of a conventional airplane.

ERIC SCHULZINGER

sachusetts Institute of Technology in Cambridge, Massachusetts: a jet engine the size of a shirt button. Components of such engines have actually run in test beds. The baseline design involves a single centrifugal-flow compressor spinning at 2.5 million rpm on gas bearings. Combustion takes place in a doughnut-shaped chamber surrounding the engine, and the exhaust gas flows back inward toward the center through a turbine. A starter-generator is built into the case; if needed, the engine could serve as a tiny electrical generator, putting out 10 to 20, or perhaps as much as 100 watts, or it can be used as a jet engine with a thrust of up to a third of a pound.

The key to making such a device cheaply and in large numbers is a version of the same photolithographic manufacturing technique used at Caltech to make the wings of the Microbat. Engine parts would be etched in sheets of silicon, like microchips. (By the early 1990s, electric motors smaller than the point of a pin, invisible to the naked eye, had already been made by this technique.) Just one micro-engine would be sufficient to supply both the thrust and the electrical requirements of a present-day MAV.

At the Georgia Institute of Technology Aerospace Laboratory, Robert Michelson leads a project to develop and refine an entomopter, a machine that will not only fly like a bug

COURTESY AEROVIRONMENT

MicroSTAR (top) will weigh less than four ounces yet range three miles for 20 minutes. A see-through model of an early Black Widow shows its complete avionics system fabricated on a single circuit (above).

K.CHIANG/D. PICK

This micro-mechanical flying insect design, shown here in an artist's conception, would be powered by actuators that flex like muscles when an electrical charge is applied, flapping a pair of wings spanning only 10 inches. A team at the University of California at Berkeley is developing the concept.

CHAD SLATTERY

ILAN KROO

Working with MAV parts is like watch-making (left). Stanford's mesicopter (above) has four rotors, and its electric motors and avionics are combined in a single microchip.

C.C. LIN AND M.A. SCHMIDT, MIT

Vanes and rotors of this tiny turbojet produce centrifugal flow; combustion occurs on the periphery. The shirt-button-size unit can make one-third pound of thrust.

ROBERT MICHELSON

Straight from a three-dimensional computer drawing at the Georgia Institute of Technology's stereolithography machine and fresh from immersion in an epoxy bath, a pair of delicate entomopter wings is born.

but, if need be, crawl like one too. The entomopter has a "chemical nose" and other features to permit it to home in on certain kinds of targets. Its builders expect to provide it with navigation and obstacle-avoidance skills as well. But the present centerpiece of the project is its power plant, a device called a reciprocating chemical muscle.

The RCM is something like the piston and cylinder of a steam engine, except that the gas that drives it comes not from combustion but from a chemical reaction. The energy available from the chemical fuel is much greater than that available from current batteries. And the chemical reaction also has the advantage of versatility: Its waste heat can be converted into electricity to operate onboard sensors and transmitters, and spent gas can be vented over the wings to provide differential lift and, therefore, flight control.

By calling their prime mover a "muscle," the Georgia researchers underscore their reliance on the guidance of Mother Nature. "Nothing in nature achieves sustained flight with fixed

wings or with propellers," observes Michelson. "All tiny creatures flap their wings continuously. Flies don't glide."

A similar project, called the Micromechanical Flying Insect, is under way at the University of California at Berkeley, where a team headed by biologist Michael Dickinson has shed light on how insects use their wings. To simulate the Reynolds number of insect flight, Dickinson and co-workers built and instrumented a pair of 10-inch wings driven by six separate actuators, and have observed them flapping in a tank of mineral oil. In addition to a new understanding of very-low-Reynolds-number aerodynamics, such work has spawned a new vocabulary for talking about flight phenomena, with terms like "delayed stall," "rotational circulation," and "wake capture."

Wing flapping works in several ways to provide insects with a flying ability that would be the envy of any fighter pilot. To start with, the flapping of wings plays the same role as the spin of a helicopter's rotor: It creates a relative wind over the lifting surface even while the vehicle—or bug—is standing still. But flapping also sets up tiny vortices that take the place of the cambered flying surfaces, high-lift devices, and moveable flight controls of fixed airplane wings. The eddies set up by their wings not only keep bugs aloft but also allow them to hover, fly backward or sideways, and turn on a dime (or the corresponding currency of the bug world).

Putting the new understanding to practical use is the next step, and not an easy one. The Berkeley team, with some sponsorship from DARPA, proposes to duplicate, in a mechanism about the size of a quarter, at least some of the abilities of a large, repulsive, carrion-eating fly called *Calliphora*. "You can't build [robot insects] now based on known principles," Dickinson has said. "You have to fundamentally rethink the problem."

Most of the proposed uses for MAVs are military; the funding, after all, is coming from the Department of Defense. But some workers in the field propose broader applications for tiny flying robots. Georgia Tech's Michelson has suggested sending robot "terminators" after real-life insect pests, but suspects that the largest potential outlet for small aerial robots might be the toy market. Stanford's Ilan Kroo leads a team developing a "mesicopter," a multi-rotor electric helicopter. Currently of centimeter size but potentially much smaller, the mesicopter is shaped like a thin, square wafer with a little rotor at each corner. Essentially a flying microchip, a mesicopter's motors, sensors, guidance, and telemetry systems would be etched in place in a single completely automatic manufacturing operation. Kroo's team envisions swarms of mesicopters investigating the interiors of storms or the atmosphere of Mars.

The word "swarm" is particularly significant. Of course, it suggests insects, and much of the more startling MAV research is headed in the direction of emulating those successful products of natural selection. But it also alludes to nature's profligacy. Many creatures that live in hazardous environments reproduce in huge numbers so that just a few may survive to maturity. MEMS manufacturing techniques imply a similar approach to machines. Rather than launch a single costly, sophisticated, man-carrying device to do a job, you would launch hundreds of simple, cheap robots. If most of them fail, no matter—they are expendable. Only one needs to complete the task.

A case in point, reminiscent of the wholesale egg-laying habits of marine creatures, is what Kris Pister of the Berkeley program calls "smart dust." Consisting of various kinds of motion or chemical sensors, a power supply, a microprocessor, and a system of communication, all packed into the volume of a grain of coarse sand, these "motes" would be sprinkled randomly over a wide area to report back what they find. What would do the sprinkling and receive the reports? A MAV, of course.

The use of MEMS in the construction of miniature aircraft is likely to bring about, in the next decade, innovations that seem incredible today. The button turbojet could revolutionize propulsion, even if only for model aircraft builders. Soldiers fighting in blasted cities in central Asia will be grateful for the ability to look around corners with tiny airborne cameras. Children will shriek with delight as their robot wasps attack a neighbor's action figure.

But will we have to wonder, even in civilian life, whether every persistent fly we encounter is carrying a listening device?

STANLEY LEARY/G I T.

Robert Michelson's reciprocating chemical muscle test bed at the Georgia Institute of Technology flaps its wings whenever he feeds it a meal of liquid fuel.

Window on the World

The most important piece of glass on the International Space Station.

by Leonard David

NASA has certainly taken travel photography to new heights over the years. Beginning with the Mercury missions of the early 1960s, camera-toting astronauts have snapped more than 400,000 pictures of the globe, documenting everything from natural events to the impact humans have had on the environment to, well, the simple beauty of Earth from space.

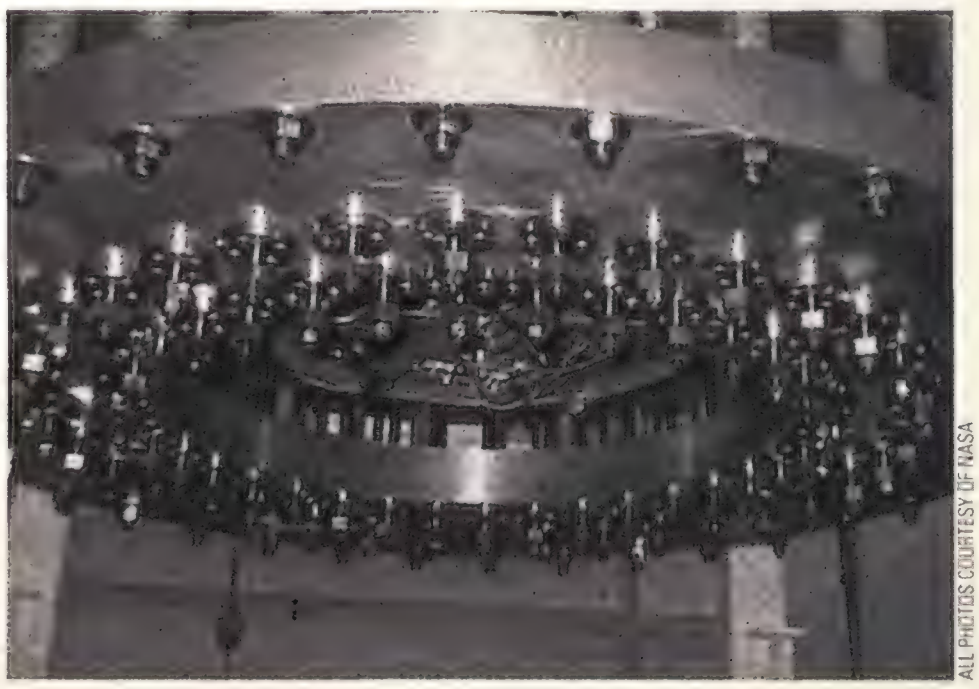
But while the images made by orbiting astronauts are visually stunning and often scientifically rich, they are usually far from perfect. The problem is that even though the astronauts have excellent photographic equipment, they're shooting through glass designed to stay intact under the pressures of space travel, rather than to allow photographers to capture fine detail several hundred miles away. It's a little like buying a top-of-the-line Nikon or Hasselblad and then mounting a piece of thick household window glass to the front of the lens.

But now there's a new photo opportunity on the horizon. When the U.S. Laboratory Module of the International Space Station (ISS) becomes operational—its launch date depends on that of the Russian-built service module—astronauts will study the planet through the highest quality optical window ever installed in a crewed spacecraft. This 20-inch-diameter circular window, which has been designed and manufactured to eliminate the distortions that plague conventional glass, will be the centerpiece of an active program of Earth observation and photography—and the culmination of a decades-long battle waged over a little bit of glass.

The view from the station will be striking. For starters, its path will give its crew plenty to look at. The ISS follows an orbital track inclined 51.6 degrees from Earth's equator. That means it is flying over more than 75 percent of the planet's surface, an area containing 95 percent of the world's population. Thus, the U.S. Laboratory, along with its nadir window facing Earth, offers a vantage point from which to monitor, with specialized equipment, the global environment. "On the space station, we have people who are highly trained, very curious, and interested in doing something useful out the window," says longtime window proponent Dean Eppler, a senior scientist in the Houston office of Science Applications International Corporation, a NASA program contractor. "By taking advantage of a good window, along with the interactive capability of the brain—the human computer—we will have an interactive remote sensing laboratory in space, and that's a unique thing."

NASA selected Corning, Inc., a high-performance glass veteran—and producer of windows for every manned NASA space program—for the job. "This is the best space window we have manufactured, and it was no small feat," says Larry Sutton, space products account manager for Corning in Canton, New York. Design and fabrication of the window took Corning a year, with two other firms helping to deliver the final product, a four-piece assembly consisting of a tough, micrometeorite-resistant outside pane, primary and secondary panes that serve as the optical heart of the window, and a protective interior "scratch" pane. The assembly features external and internal shutters to further protect the glass. As scratches and contaminants accumulate, the external pane can be re-

A hint of what's to come: Grand Bahama Island seen from the space shuttle (opposite). To secure the window inside the station, engineers created a high-strength frame (below).



ALL PHOTOS COURTESY OF NASA

moved by spacewalking astronauts, returned to the ground for repolishing and recoating, and then reinstalled. The interior scratch pane, which protects against bumps from cameras and other instruments, can also be replaced.

The window's glass is a special stock of high-purity, colorless, synthetic fused silicon dioxide—a material chosen for its resistance to the effects of thermal variations and its exceptional light transmission. Corning took extra care in producing the glass, making sure that tiny imperfections such as bubbles and other blemishes were minimized. The homogeneity of the window is very high—light waves pass through the glass with barely any distortion. A polishing job by Zygo Corporation, a high-performance testing, manufacturing, and measurement firm in Middlefield, Connecticut, made the glass almost perfectly smooth, and coatings by Optical Coating Laboratory, Inc., of Santa Rosa, California, will block out harmful ultraviolet radiation and enhance light transmission to give the space window its unequalled optical rating. "For the astronauts to be able to see without the distortion is going to be amazing," Sutton says.

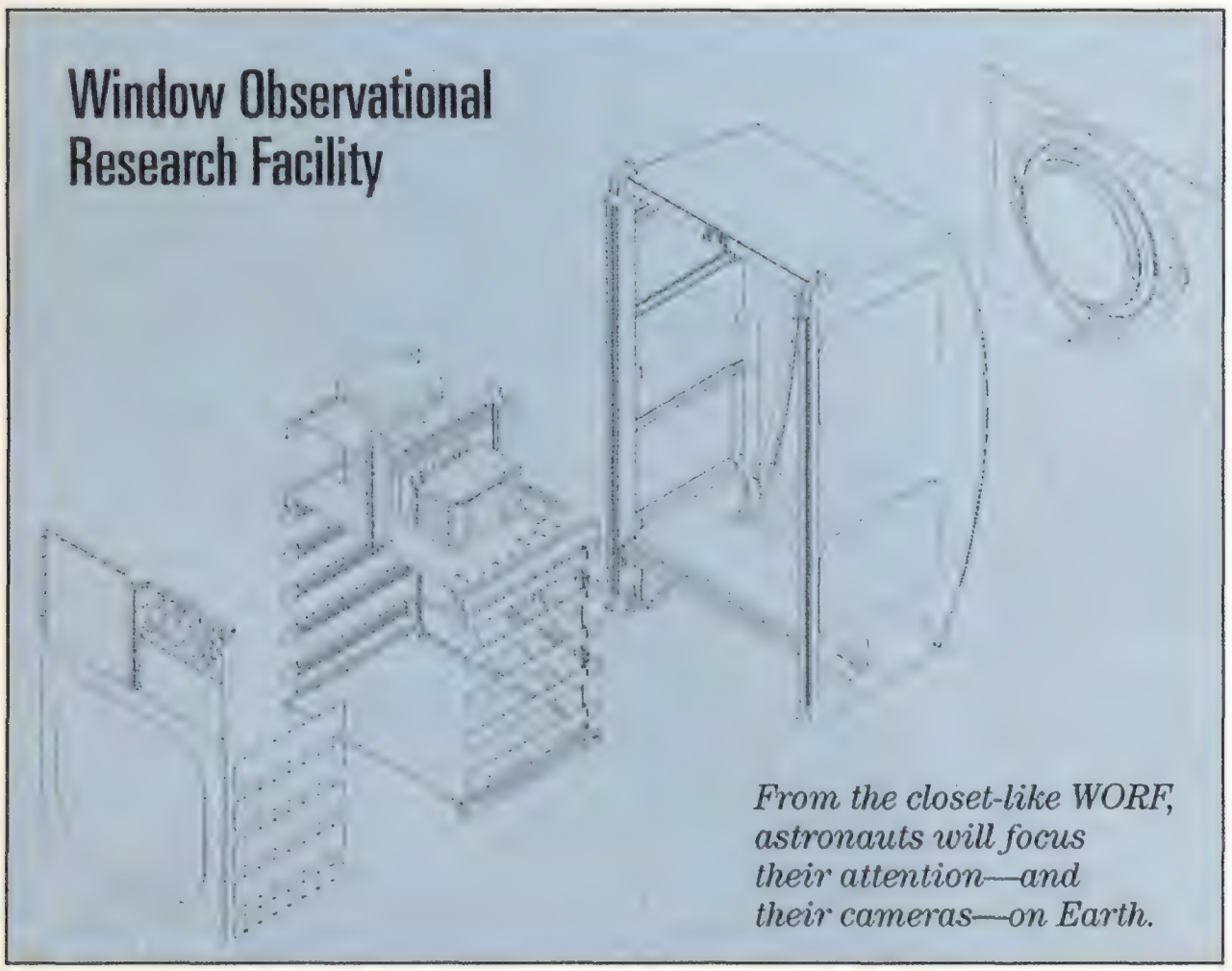
To take full advantage of the station's high-quality port, engineers have designed a work closet to enclose the window. The closet—the Window Observational Research Facility—is a maneuverable open rack that will help position and operate all of the cameras, sensors, telescopes, and other equipment. Fit flush against the lab's wall, the WORF will be installed after the U.S. Laboratory is itself in orbit and will frame the window. "Everything is going to be aimed at the center of that window, the sweet spot," explains Scott Britnell, a lead technician working on the enclosure at Boeing Missiles and Space Division in Huntsville, Alabama. The WORF has a black interior to stop stray light from fouling sensitive devices aimed out of the viewing port, and to reduce stray glare from the lab itself, a flexible shroud, similar to a splash skirt on a kayak, fits tightly around the waist of the astronaut working at the window. Depending on the bulkiness of equipment installed within the rack, Britnell says, there may be enough room to squeeze three people inside. But, he adds, they'd better be pretty good friends.

Once in orbit, the lab window will be face to face with Earth's surface most of the time. Those peering through the nadir window are promised an eyeful—a more color-true and vivid Earth, rich in detail and there for the taking, photographically speaking. Though the images won't be any better than those from cameras mounted outside spacecraft, they will be far superior to previous hand-held efforts. This is key, as experience has shown that using the astronaut's eye often produces better results than relying on remotely controlled equipment.

To date, though, camera work by astronauts has largely been a recreational activity practiced at the crew's discretion, rather than a dedicated scientific duty. Former astronaut Story Musgrave, for example, sheepishly admits to doing whatever it took to get time at the shuttle windows: "I've got a lot of window time. You don't eat. You stuff your pockets and eat at the window," he says. Mary Cleave, who twice rode on *Atlantis*, says that such discretionary window time often produces important scientific observations. Now a deputy associate administrator at NASA's Office of Earth Sciences in Washington, D.C., Cleave points out that the photographic record from successive shuttle flights clearly shows changes on Earth throughout the years, such as deforestation patterns and sediment accumulation around river deltas.

In one observation, an astronaut documented a then-theoretical phenomenon in oceanography called standing wave packets. "Nobody had ever seen them because they were too big to see from an airplane," Cleave says. Standing waves occur when there is a tidal surge through a constriction, like the Straits of Gibraltar in the Mediterranean. "During the Second World War, the Germans used to get their U-boat submarines into the Mediterranean and back out again by surfing these waves, which they had figured out," Cleave says. Thanks to sharp-eyed Apollo-Soyuz astronaut Vance Brand, orbiting in 1975, the standing waves were captured on film. "He looked down and saw something strange and took a picture of it," Cleave says. "Sure enough, it was these standing packets of waves, which are now called V-brand waves."

In the space station era, Earth science studies will be routinely carried out by astronauts as part of their re-



From the closet-like WORF, astronauts will focus their attention—and their cameras—on Earth.

search workload. Protracted spaceflight—as demonstrated by astronauts and cosmonauts who lived aboard the Russian space station Mir—will allow astronauts to become far more sensitized to Earth's workings. "There is no question that the longer a person stays in space, the more they pick up some of the subtle rhythms of the planet," says Cynthia Evans, manager of Lockheed Martin's Houston-based Office of Earth Sciences. As a NASA contractor, she teaches astronauts to become "Earth smart" by instructing them to be on the lookout for phenomena of scientific interest. Her office will also keep station astronauts informed, via daily updates and Internet messages, about current environmental events to maximize the astronauts' time and to take advantage of the crystal clarity that the new window provides. Ice packs, volcanoes, developing typhoons, snow lines on the continents, biomass burning in northern forests, and the stirrings of future El Niño events will be among the observers' targets.

In addition to such training by Evans and her team, station crews will be taught how to use the WORF—specifically, the quick installation and removal of cameras and other equipment. Years of shuttle flights have yielded insight into how the handling of cameras, lenses, film, and other accessories can be made easy for astronauts afloat in microgravity, and less of an all-thumbs hassle. Nobody wants to miss that one-of-a-kind shot.

Despite the apparent advantage astronauts have while ogling Earth from on high, securing a little room with a view aboard the station has been a hard-fought battle. It turns out that window panes in astronaut-carrying craft are a real pain to engineers. In the first place, a spacecraft hull's structural integrity is compromised by a window. "The structural engineers like to have a nice solid cylinder. They don't like poking holes into metal to put in windows," explains Karen Scott, senior project engineer at the Aerospace Corporation's office at Johnson Space Center in Houston. And windows are brittle, not as predictable, in terms of yield-strength, as, say, aluminum. In other words, glass does not fail gracefully. Battle lines were drawn long ago

Technicians apply a little tender loving care as they inspect the window prior to mounting it within the station's U.S. Laboratory (top and middle). Designers hope the window will make picture-taking less awkward than this 1994 attempt by Endeavour *astronaut Jerome Apt (above).*

between window-loving astronauts and spacecraft builders. It started with the Mercury astronauts and continued through Skylab and right into the space shuttle era. Though NASA once considered placing photo-quality windows aboard the shuttle, it nixed the idea in order to cut costs. Engineers instead installed the type of glass used in military aircraft—good enough to enable astronauts to safely pilot the shuttle to a touchdown. "They transferred those same window requirements from shuttle to the space station," Scott says. "I pointed out very early on, what we had then were windows perfect for landing the space station."

In 1995, Dean Eppler took up the cause of allocating station astronauts quality window time. He became a force in pushing for the space station's super-quality window. He and his colleagues had to haggle with administrators and persuade the engineers to cut yet another hole in their closed container, then persuade everyone to spend additional money to support the project. In 1996, when station managers green-lighted a U.S. Laboratory window upgrade, Eppler launched a funding campaign that snagged some $700,000, mostly from the earth sciences office of the Department of Defense, as well as from NASA itself.

Like Eppler, astronaut Mario Runco has been a dogged supporter of the laboratory's high-quality Earth-oriented port and has been a key force behind the design and fabrication of the WORF and the window. During Runco's three shuttle missions, seeing was believing. He found comfort in the realization that the human eye was far more sensitive than camera and film in picking up details on Earth. As a professional meteorologist and oceanographer, the astronaut was struck, for example, by formation details he noticed in a Pacific typhoon and the fact that at certain angles, sunlight reflects off the sea surface and reveals amazing detail in the subsurface structure of the ocean—and he thinks that many of his fellow astronauts don't yet realize what's in store for them. "It will be better than anything they've experienced before," says Runco, who himself isn't yet scheduled for a space station mission.

Among the scientists and astronauts focused on the window, there is also a sense that the space station's ultra-clear portal on the planet comes at the right time. Its on-duty role seems attuned to the increasing realization that environmental concern still outweighs environmental action, and that the planet has a long way to go before it can be called healthy.

Besides, a little bit of glass will ensure that homesick astronauts won't feel as though they're trapped in an orbiting submarine. "Windows are clearly one of the keys to crew sanity for long stays in space," Eppler quips.

AHEAD of their *time*

For the aircraft in this gallery, it was a case of too much, too soon.

Photographs from the National Air and Space Museum

In the race to advance aerospace technology, there have been a few false starts. Some farsighted aircraft designers learned the hard way the adage cited by the scientist in Michael Crichton's *Jurassic Park*: "Just because we *can* do something doesn't mean we *should*." Sometimes an innovation looked great on paper but not in the air. Sometimes it worked in both arenas, but just never caught on. Sometimes a great leap forward ended with two steps back. But no matter. In the hundred years since the airplane first flew, the best ideas have eventually resurfaced as the work in progress continues. We polled experts to find the aircraft that reflected some good ideas...a little too early. Here are their nominations.

Alexander Eaglerock Bullet
Nominated by Tom Poberezny, president, Experimental Aircraft Association, and Jack Cox, former editor of *Sport Aviation*

The configurational precursor to today's low-wing, four-place, retractable-gear lightplane, the Alexander Eaglerock Bullet was designed by Al Mooney (who later founded Mooney Aircraft) in the late 1920s, during his stint at the Alexander Airplane Company. Unfortunately, if the Bullet entered a conventional spin, after several turns it would progress into an unrecoverable flat spin. The design was significantly altered to meet the spin requirement for obtaining a type certificate. The original Bullet shape reappeared with a different wing in the late 1930s in the Bellanca Cruisair Junior. Down the road, all the Bonanzas, Comanches, and other light aircraft generally adhered to the airframe layout of Al Mooney's Bullet.

The airframe layout of today's light aircraft—with a spin problem.

A capable design with no capable propulsion.

Henson's Aerial Steam Carriage
Nominated by Air Vice Marshal Ron Dick (Royal Air Force, ret.)

All the essentials of a modern propeller-driven aircraft were embodied in William Henson's Aerial Steam Carriage, a design patented in 1843: twin-engine monoplane form, cambered wings, tailplane, fin, and movable control surfaces. The wingspan was 150 feet, and there was a fuselage for the carriage of passengers or cargo. The Aerial Transit Company was formed to promote Henson's dream of intercontinental air travel, and advertising showed the Ariel, as it became known, over London, China, India, and the pyramids. Henson's problem was the lack of a suitable source of power. The Ariel was intended to rely on a very heavy 25-horsepower steam engine to drive the propellers. It would never have flown, but it was a wonderful idea.

All-plastic construction: lightweight, strong, and cheap to build. Interest: nil.

Windecker Eagle
Nominated by editors, *Air & Space*

Leo Windecker, a dentist by trade, took to heart the admonition to Dustin Hoffman in *The Graduate* that the future lay in plastics. His four-place light aircraft, a 1960s creation, was composed of a form of plastic—a non-woven unidirectional glass fiber Windecker patented under the name of Fibaloy. (Piper Aircraft built an all-plastic trainer in the early 1960s, but folded the project when sun and humidity played hob with the materials.) It was lightweight, strong, durable, and easy to mold into various compound curves. All antennas were embedded in the plastic skin, making for an exceptionally clean line. By 1971, the plant at the Midland-Odessa airport in Texas had cranked out—and sold—five Eagles. But it could rustle up no more takers, save the Air Force, which ordered one to evaluate the stealth characteristics of the plastic construction. The YE-5, as the Air Force designated it, proved superbly stealthy, but after the airplane proved the point, it was retired.

Dayton-Wright Racer
Nominated by Tom Poberezny, president, EAA, and Jack Cox, former editor of *Sport Aviation*

The Dayton-Wright Racer of the 1920s employed a retractable landing gear, enclosed cockpit, and cantilever wing, all of which enabled it to achieve a speed of 178 mph on just 200 hp. Most notable were the high-lift devices on the wings, fundamentally the leading edge slats and trailing edge flap used on transport aircraft today. All the Racer's innovations would eventually come into common use, but the aircraft was a one-off design that ended up in the Ford Museum. It was strictly a closed-course racer, with, for example, virtually no forward visibility, and thus was a technological dead end.

High-lift devices, high speed, no visibility.

Concorde
Nominated by Tom Heppenheimer, aerospace writer

A joint British-French project, the Concorde sought to leap past the Yanks' subsonic jets by offering a supersonic transport (SST). The airliner that resulted was both beautiful and speedy, cruising on afterburner at Mach 2—but the sonic boom restricted it to trans-oceanic flights. And its development, production, and operational costs were stratospheric. Even before the 1970s energy crisis, Pan American and TWA, the leading overseas carriers, withdrew their deposits. In *Supersonic (Airliner) Non-Sense*, National Air and Space Museum curator Ron Davies points out that "[f]or every passenger carried across the Atlantic, the Concorde carries a ton of fuel." Only 14 Concordes entered service, all with the government-run Air France and British Airways.

Mach 2 across the
Atlantic, but nowhere else.

Fairey Rotodyne
Nominated by editors, *Air & Space*

The late 1950s Fairey Rotodyne was part helicopter, part autogyro. To drive the rotor blades for takeoff, compressed air from the two 3,000-hp turboprop engines was routed to fuel burners at the blade tips in a design similar to the Hiller Hornet, which had ramjet engines at the blade tips. Once the thing got cranking, you could shut down the tip burners and autogyrate along at 200 mph. Orders came in for production versions, but after Fairey was absorbed by Westland the program lost momentum and these orders were eventually withdrawn.

A twin turboprop helicopter-autogyro hybrid.

Gwinn Aircar
Nominated by Tom Poberezny, president, EAA, and Jack Cox, former editor of *Sport Aviation*

In the late 1930s, Joseph Gwinn, believing that an airplane that was more like a car would appeal to the public, built the Aircar. The cabin was configured to resemble that of an Oldsmobile, including foot-actuated clutch, brake and accelerator pedals, a steering wheel, and Olds instrument gauges—as well as rear-view mirrors and a two-tone car horn. To take off, the pilot accelerated down the runway until reaching flying speed (marked on the speedometer) and depressed the clutch pedal, which lowered full-span flaps and launched the aircraft. With the Aircar certified for no-flare landings, the pilot simply steered down the runway, adjusting the glide path with the foot accelerator until touchdown. The project came to an abrupt end in 1938 when demo pilot Frank Hawks crashed, killing himself and a passenger. The adverse publicity dried up sources for financing. Another factor that weighed against the Aircar: It was one of the homeliest aircraft ever conceived.

For the masses:
an airplane that felt like a car.

A 140-mph aluminum airliner,
scrapped at a tender age.

COURTESY PETER M. GROSZ

Staaken E.4/20
Nominated by Peter M. Grosz, aviation historian

Germany's Staaken E.4/20 was the world's first modern transport aircraft. Its functional lines belie the fact that it was built in 1920. The E.4/20 owed much to the all-metal monoplane bombers that Staaken was developing in 1918. In contrast to the wood-and-fabric civil aircraft of the post-war era, the E.4/20 was constructed with techniques very similar to those used today. The airframe was built from specially formed duralumin alloy profiles riveted together and covered with a thin riveted duralumin skin. Completed in September 1920, the E.4/20 performed a number of exceedingly promising test flights. In one, under optimum conditions, the aircraft was clocked at 140 mph, an unheard-of speed for an aircraft of that size. Further test flights were prohibited by the Inter-Allied Control Commission, which realized that the E.4/20 had military potential and thus violated peace treaty terms. It also refused to let the aircraft be sold or given away, leaving Staaken no recourse but to scrap it.

A 26-passenger long-range transport,
dashed by its builder's grandiose visions.

Lawson Airliner
Nominated by Richard P. Hallion, U.S. Air Force Historian

Alfred Lawson started the Lawson Aircraft Company of Green Bay, Wisconsin, at the end of World War I. Convinced that the future of civil air transport demanded specialized aircraft, not crude modifications of bombers, he directed his engineers to draw up a twin-engine biplane with an enclosed cabin and cockpit. The C-2, the first practicable multi-engine passenger airplane designed in the United States, carried 26 passengers and had a range of 400 miles. In the summer of 1919, Lawson and pilot Charles Wilcox, accompanied by the design team, made a demonstration flight from Milwaukee to Washington, D.C., stopping at major cities along the way. Had Lawson made more demo flights and put the C-2 into production, he might have added an impressive chapter to the annals of aviation. Alas, his quirky nature, favoring the grandiose over the sensible, overcame reason. He shelved the elegant C-2 and sank his remaining money into a larger tri-motor biplane. On May 8, 1921, Lawson and Wilcox crashed the Lawson L-4, which brought the saga of the Lawson Airliner project to an end.

Martin XB-51 Panther
Nominated by Cam Martin, external affairs director, Dryden Flight Research Center

This early 1950s bomber looked like a fighter, flew as fast as a fighter, and maneuvered and handled like a fighter. It even starred as a fighter—the fictional Gilbert XF-120 in the classic test pilot movie *Toward the Unknown*. The XB-51 had numerous novel features: T-tail, engines in pods on the forward fuselage, third engine in the tail, rotary bomb bay, variable-incidence wing, spoilers instead of ailerons, and bicycle-type landing gear. But all these cool features also made it very expensive, and in the long run, it did not meet the mission range and loiter requirements as well as its competitor, the English Electric Canberra—which Martin was ultimately licensed to produce as the B-57.

A bomber that thought it was a fighter, with all the bells and whistles.

Sleek, speedy, and intimidating.

Lascuráin Sonora
Nominated by Dan Hagedorn, Adjunct Curator, Latin American Aviation, National Air and Space Museum

The Sonora Monoplane, designed by Angel Lascuráin and built at Talleres Aeronáuticos at Mexico's Balbuena Airfield in 1921, was the first low-wing cantilever monoplane in Latin America and one of the first in the Western Hemisphere. The military trainer first flew on March 7, 1922, and was credited with a maximum speed of 190 mph, phenomenal for the time. Only five were built—that was all the Mexican air force could afford. One suspects, too, that because it was a hot airplane, it may have been a little intimidating for trainees, who were probably more comfortable with the biplanes of the day.

For most of last year, aviation photographer Erik Hildebrandt made airshows his mission. From April to October, he traveled the circuit with the pilots and their crews, documenting their acrobatics from the ground, capturing them in tight close-ups in the air, and devising other ways to record the performances that bring the fans to watch these pilots every year. "The point of the project is to show the whole story of the airshow, and to do it within the span of a single season," Hildebrandt says. The result has been published in a book entitled *Front Row Center: Inside the Great American Airshow*, now available from Cleared Hot Media.

In the end, Hildebrandt spent almost as much time in the air as his subjects. At the Moffet Airshow in northern California, Hildebrandt, flying in a Piper Cherokee, used a mid-exposure zoom technique to capture a dramatic image of Wayne Handley in his Oracle Turbo Raven, a high-performance, hand-built, carbon-fiber stunner (opposite). The aircraft was destroyed in early October of last year when the engine lost power during a performance at the California International Airshow in Salinas. The pilot was seriously injured, but is well on the way toward recovery—and in fact has already flown again. At the same show, Hildebrandt glimpsed aviation's future: a propeller beanie-topped tyke ready to launch a styrofoam Skyfighter (right).

On the opposite coast, the photographer caught up with the Northern Lights during the Rhode Island Air National Guard Show at Quonset Point (below). Riding in a DC-3 above Long Island, New York, Hildebrandt photographed the five Extra 300s, led by Andre Lortie (number 1) and Mario Hamel (number 2), flying in skintight formation.

ERIK HILDEBRANDT/ERIK@VULTURESROW.COM

Electra Complex

Amelia Earhart: The Mystery Solved

by Elgin and Marie Long. Simon & Schuster, 1999. 320 pp., $25.00.

Because of its title—and since we are not yet looking at a newly found Lockheed Electra with the tail number NR 16020—*Amelia Earhart: The Mystery Solved* may appear to be only the latest pseudo-theory in the long-running search for Amelia Earhart and Fred Noonan (below, far right, with, from left, Paul Mantz, Earhart, and Harry Manning). After 60-plus years of theories involving espionage, Japanese execution, an errant shoe on an island, or life on a Philippine rubber plantation or as a New Jersey housewife, the general public may be forgiven if it shouts "Show me the money!" Or, in this case, "airplane!" However, it would be wrong to put this book in that category. Elgin and Marie Long have developed a reasonable hypothesis that could lead to the discovery of the long-lost aviator's aircraft. The authors present a detailed and promising, if highly technical, study, but they stop short of revealing the precise location of the area where they think the Lockheed is, as they hope to search the region this year in cooperation with Nauticos, an ocean exploration company.

The authors have been researching Earhart's disappearance for 25 years and bring with them solid research and writing skills and, in Elgin's case, a long and record-breaking aviation career. Elgin, a 40,000-hour pilot, was one of the last airline pilots to earn a navigation rating on a Pan American Boeing 314, and ended his career flying Boeing 747s. He was also the first person to make a solo flight around the world over the North and South Poles. Marie handled publicity and logistics from home, sort of a reversal of the roles Earhart and her husband George Putnam assumed. The authors combine their experience with first-person interviews of crew members of the *Itasca* (the ship that was in contact with Earhart before she disappeared), friends and family of Earhart and Noonan, and technical experts, as well as exhaustive analysis. The result is a book that makes a case for explaining perhaps the most famous disappearance of the 20th century.

Some of the information presented is well known. But even veteran Earhart watchers and historians will learn a lot more. The Longs detail the complexities of Earhart's new Bendix receiver (as opposed to a Western Electric model, as others have stated) and the radio direction finder. The first key to the tragedy was the inability of Earhart and the radioman who briefed her in California to completely understand the operation and interaction of the aircraft's radio systems. Clearly another major mistake involved Earhart's decision not to carry a 250-foot trailing wire that would have allowed her better communication with ships operating around the world. We are led to believe that she thought another antenna would work, but it did not. Most critical was the inability of either crew member to use Morse Code. The lack of a flight director or radio operator to manage the communication between Earhart and the *Itasca* contributed to the situation.

In the end, Noonan apparently got them tantalizingly close to Howland Island. However, when the two aviators could not locate it—their maps turned out to be faulty—they were not familiar enough with their equipment to enable the *Itasca*, anchored next to the island, to take radio bearings on the Lockheed. According to the Longs, reasonable navigational error put Earhart west and possibly north of Howland, forcing Noonan to make desperate choices in his search for the island in the face of a dwindling fuel supply.

The Longs believe that the Electra will be found not far to the west of Howland. First of all, they believe Earhart was

NASM

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Take a look around the launch pads and rockets of America's first spaceport.

correct when she radioed the *Itasca*, "We must be on you, but cannot see you," and the strength of her radio signal as received by the ship confirmed that she was very close. The book's analysis of Noonan's navigation and his recommendations for finding the island may be a bit too detailed, but the authors make their point. Those without a vast working knowledge of the minutiae of the disappearance will be overwhelmed, but all the detail may be what is required to truly understand what went wrong.

Although the aircraft would make a very small footprint on the vast ocean floor, the technology to find it exists. Recent deep-water discoveries include the U.S. carrier *Yorktown* and three Japanese carriers sunk at the Battle of Midway. Experts believe that the aircraft is in about 17,000 feet of water and that it may be intact or in several large pieces. No World War II battles were fought in the area, nor is the region in shipping lanes, so the bottom should not be cluttered or disturbed.

This is the sort of solid study that should prepare the way for high-tech searchers to find the aircraft and write a conclusion to the story. Once the Electra is found, we will be able to concentrate on Amelia Earhart's true legacy, her lasting contributions to aviation and women. Not to mention her courage.
—Dorothy Cochrane is a curator in the aeronautics department of the National Air and Space Museum.

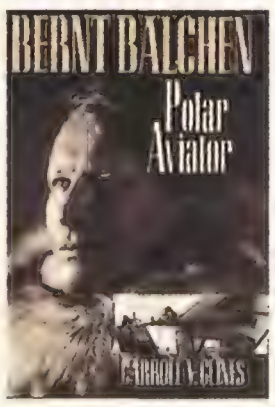
Bernt Balchen, Polar Aviator

by Carroll V. Glines. Smithsonian Institution Press, 1999. 310 pp., b&w photos, $29.95.

As George Weiss notes in his foreword, "Bernt Balchen is one of the least recognized public figures in America, yet he was a hero to individuals the public called heroes. He was a leader of those who called themselves leaders." For just that reason I hinted to my daughter that this book would make a fine Christmas present. I wanted to know more about this character who kept appearing in adventures around the globe for four decades.

Glines, a noted aviation biographer of such legends as Roscoe Turner, does a good job of filling in the blanks. He relates what happened in the seven years before the young Norwegian was present at the fateful 1926 meeting in Spitsbergen of polar aviation giants Roald Amundsen, Umberto Nobile, Lincoln Ellsworth, Richard Byrd, and Floyd Bennett. After brief service in the French Foreign Legion in World War I, Balchen was almost killed in a Finnish cavalry charge against the Russian army. In 1921, Balchen qualified as a pilot in the Norwegian navy. His training as an arctic outdoorsman and his intellectual and physical stamina were the attributes that prepared him for his lifelong career.

Glines describes how these qualities became apparent to Byrd, Bennett, and Tony Fokker. Balchen was especially qualified to tackle a tough flying job, expecially if it was in the high latitudes.



Byrd might have never made it to France in 1927, or to the South Pole in 1929, had Balchen not been the pilot. And perhaps most ironically, it was Balchen's expertise with ski-equipped aircraft that permitted Byrd's Fokker to lift off Spitsbergen's ice on its North Polar flight in 1926. Ironic because, as Glines abundantly details, the two polar heroes' relationship was ultimately destroyed, with Byrd hounding Balchen for garnering too much publicity and Balchen revealing, just after Byrd's death, his belief that Byrd had not reached the North Pole in 1926 as he had claimed, but rather had turned back far south of his goal.

Glines makes this conflict the theme of his book, but also delves into many other Balchen exploits that didn't involve Byrd. He devotes several chapters to Balchen's pioneering air base construction and search-and-rescue activities in Greenland for the U.S. Army, beginning even before the United States entered World War II, including his leading a long-range bombing mission from Iceland to a German base in northeast Greenland. Also particularly fascinating is Glines' description of Balchen's cloak-and-dagger exploits later in the war, when the aviator commanded a fleet of green-painted, civil-registered B-24s flying to neutral Sweden, and black-painted Army B-24s flying to German-occupied Norway.

The author's research was diligent, so it is unfortunate that several errors are detectable—an obvious mis-identification of an airplane in a photo caption (a problem that seems to plague all aviation books)—and confusions of dates, places, and people. A book describing flights to far-flung exotic places could also have used more maps. Still, I recommend the book for its well-written description of a fantastic life and the incredible vendetta one hero—Byrd—carried out against another—Balchen.
—Sam Smith is a commercially licensed pilot and amateur aviation historian.

ON TELEVISION

Air Rescue

Premieres Saturday, April 15, at 10:00 p.m. (EST/PST) on the History Channel.
The history of helicopter rescue.

Rocketeers

Premieres Friday, April 12, at 8:00 (EST/PST) on The Learning Channel.
Amateur rocket enthusiasts compete.

Pararescuemen

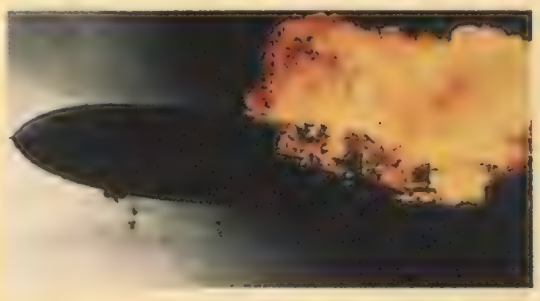
Premieres Wenesday, April 5, at 8:00 (EST/PST) on Discovery Channel.
The grueling training of pararescuemen.

Spy Planes

Premieres Sunday, April 16, 11:00 p.m. (EST/PST) on the History Channel.
A look at U-2s, SR-71s, and other sky spies.

What Happened to the Hindenburg?

Premieres Wednesday, May 17, at 8:00 p.m. EST on PBS.
Examines new evidence that the *Hindenburg* tragedy was caused by the airship's aluminum-impregnated skin, not by the hydrogen in its envelope (see From the Field, April/May 1997).



CALENDAR

April 7–9
Cox Communications Air Show Spectacular. Williams Gateway Airport, Mesa, AZ, (480) 774-9355.

April 29
Marine Corps Air Station New River Airshow. Cherry Point, NC, (910) 450-5497.

April 29 & 30
Spirit of Flight Air Show & WalkAbout. Galveston International Airport-Scholes Field, Galveston Island, TX, (409) 762-3930.

May 1–July 16
Millennium Festival of Flight. Museum of Flight, East Fortune Airfield, East Lothian, Scotland, phone 01620 880308, www.nms.ac.uk/flight.

May 3
New Jersey State Aviation Conference. Officers' Club, McGuire Air Force Base, NJ, (609) 530-2900.

May 4
Space Day. Activities include a live interactive Webcast from the National Air and Space Museum in Washington, D.C., and a project that launches student signatures into space aboard future shuttle missions. For more information, visit www.spaceday.com or call (202) 833-8121.

May 6 & 7
Air & Sea Show: "A National Salute to the U.S. Military." Fort Lauderdale Beach, FL, (954) 527-5600, ext. 88.

May 13 & 14
EAA Georgia Wings Fly-In & Expo. Gwinnett County Airport, Briscoe Field, Lawrenceville, GA, (770) 613-9501.

May 14–17
Reunion: P-47 Thunderbolt Pilots Association. DeSoto Hilton, Savannah, GA, (912) 598-1333.

May 18–21
Reunion: 446th Bomb Group, 8th Air Force, World War II, Arlington Hilton & Towers, Arlington, VA, (714) 832-2829.

May 19–22
Hang Gliding Spectacular and Air Games. Jockey's Ridge State Park, Nags Head, NC, 1-877-FLYTHIS.

May 20
Marshall Space Flight Center Open House. Huntsville, AL, (888) 901-NASA.

May 20 & 21
EAA Chapter 186 Spring Fly-In. Winchester Regional Airport, VA, (703) 780-6329.

May 27 & 28
Wheels and Wings Air/Car Show. Millville Airport, NJ, (856) 327-2347.

CREDITS

Man Overboard! Keith Monroe was an executive at Ryan Aeronautical in San Diego when the incident he writes about occurred.

The Western Canadian Ramjet Co. A retired engineer living in Sequim, Washington, Gordon J. Twa worked on such aerospace programs as the F-106 and Saturn/Apollo.

HUEY. John Sotham is an associate editor at *Air & Space/Smithsonian.*

Vietnam Vets. Illustrator Harry Whitver designs the covers for *Air & Space.*

High Mileage. Writer and pilot Mark Huber lives in Michigan's Upper Peninsula.

Contributing editor Chad Slattery has photographed everything from Stearmans to Sukhois, but his favorite ride is still the Goodyear blimp.

Lightning Strikes Cape Town. The managing editor/producer of "Aviation Week," a new program on Discovery's Wings Channel, William Garvey is also co-editor of *Wild Blue*, a just-released aviation anthology.

Starz in the Hood. Michael Milstein wrote "Signs of Light" (Aug./Sept. 1999), an article about the optical search for extraterrestrial intelligence.

Microspies. Peter Garrison writes about aeronautics when he is not designing and building airplanes.

Window on the World. Leonard David, a senior writer for space.com, has been writing about worldwide space activities since Sputnik 1 was launched.

Malta's Work in Progress. Tom Huntington, the former managing editor of *Air & Space*, is now the editor of *American History.*

ON THE WEB SITE

www.airspacemag.com

Immortal Beloved

Where can you see a DC-3 today? For a list of museums and operators, check out the *Air & Space* Web site, where you will also find portraits of the airliner and its military cousins from the archives of the National Air and Space Museum.


CHAD SLATTERY

MAV Links

Micro Air Vehicles are taking wing at engineering laboratories and universities across the country. Get the latest buzz by clicking on the links at the *Air & Space* Web site.

FORECAST

In the Wings...

Korean War Album
The airplanes, the operations, the heroes, the legacy: In this special section, with a time line of significant events, we remember the forgotten war.

This Space for Sale?
The Russians have done it on Mir. Is there any reason why NASA shouldn't make the International Space Station available to advertisers?

The Last Sniffer
The U.S. Air Force was about to retire the only aircraft in its fleet capable of detecting evidence of a nuclear explosion when India and Pakistan tested bombs. Operation Constant Phoenix flies again.

Flying Colors
Have you seen those wildly painted airliners flying around in the skies today? Well, it all started—wouldn't you know it?—in the '60s.


GEORGE HALL/CHECK SIX

The Empire State Airship Port?
The profile of New York's most famous skyscraper had its beginnings in a plan to dock dirigibles above the 85th floor.

JOHN HEINLY

Malta's Work in Progress

It was the Battle of Britain, Mediterranean-style. During the height of the siege, the island of Malta—a British possession 60 miles south of Sicily—was pounded by German and Italian bombs. "During two months, March and April 1942, the tonnage of the bombs dropped on Malta was twice that dropped on London during the worst of the whole year of the blitz," wrote Ernle Bradford in *Siege: Malta, 1940–1943*.

Hitler wanted to bomb Malta into submission because the island was becoming a nuisance. By November 1941 its submarines, ships, and aircraft were sinking more than 60 percent of the supplies earmarked for Erwin Rommel's Afrika Korps. As in Britain, Spitfires and Hurricanes flew to defend the island. "It all makes the Battle of Britain and fighter sweeps seem like child's play...nowhere is there aerial warfare to compare with this," wrote one Royal Air Force pilot stationed at the Ta'Qali (the "Q" is silent) airfield.

Today the base is long gone, vanished beneath unkempt fields. There's a crafts center here now, where vendors sell their works from some of the field's old Nissen and Romney huts, which were built by the Royal Air Force. But Ta'Qali's aviation heritage hasn't completely disappeared. Members of a local club meet here to fly radio-controlled models, and two huts behind the Maltese soccer stadium house the Malta Aviation Museum. Inside the little huts are a Spitfire, an Italian Fiat G-91, a Beechcraft 18S, a C-47, an Armstrong Whitworth Sea Hawk jet fighter, a Vampire T11, and several engines. In a separate room is a Link trainer that introduced countless World War II pilots to a cockpit, and a Hawker Hurricane in the process of being reconstructed. There's also a replica of the tiny French Pou du Ciel (Flying Flea), a 1930s cheap and simple homebuilt airplane for Everyman.

The Malta Aviation Museum Foundation, run by volunteers, opened the museum in 1996. "We were basically the only nation in the world not to have an aviation museum," says museum director Ray Polidano (Malta gained its independence from the United Kingdom in 1964). So aviation enthusiasts on the island joined forces to create the foundation, and kicked things off by rebuilding the Spitfire. During the war it had flown in North Africa, then out of Ta'Qali during the invasions of Sicily and Italy. A gale blew the airplane into a quarry in 1947 and the RAF wrote it off. After being vandalized, the Spitfire ended up with Malta's Air Scouts (a branch of the Boy Scouts) and later with the civil defense. In its latter life, rescue workers used it for training purposes, wrecking it in the process.

With funding from Malta's Mid-Med Bank, aviation foundation members spent nearly three years reconstructing the craft. Some replacement parts were recovered from war wreckage; still more were built from scratch. Polidano himself contributed a Spitfire wingtip and the undercarriage fairings that once hung on his garage wall.

The Malta Aviation Museum, Ta'Qali. Malta Aviation Museum Foundation, PO Box 241, Valletta, Malta GC. Phone (356) 416095. Open daily, 9:00 a.m.–5:00 p.m. (including public holidays). Admission: One Maltese lira (about $2.50).

The Hawker Hurricane that the foundation is working on requires more work than did the Spitfire. It is now little more than a metal skeleton. Flown to Malta in June 1941, the Hurricane ditched in the sea near the island's Blue Grotto less than a month later, when the engine failed. Pilot Thomas Hackston was able to get out of the airplane but disappeared. "It's quite treacherous where he landed," Polidano says. "I suspect he tried to make it to shore and never made it, or else he waited for the Air-Sea Rescue launch to come by and it never did."

For the next 50 years or so the Hurricane sat on the seabed until a fisherman tangled his nets in the wreckage in 1995 and sent a diver down to investigate. Says Polidano, "We were doing the Spitfire at that time so he came around and said, 'If you need Spitfire wings, I found a pair on the seabed.' He showed us a video and it turned out to be a Hurricane."

Unlike the Spitfire and the Hurricane, the museum's Italian Fiat G-91 has no links to Malta—it's just a cool airplane. Italy developed the Gina in the 1950s for a competition to serve as a NATO ground attack jet. The sporty little jet proved highly maneuverable, and models were later used by the Italian aerobatic team Frecce Tricolori. The museum received an R model thanks to the efforts of the commander of the Italian Military Mission in Malta.

Both the C-47 and Beechcraft 18S started their careers with the U.S. Air Force, and both ended up facing destruction when they were purchased by a fire and safety school. The foundation talked the owners into swapping the aircraft for four big containers that served firefighting education just as well. Another Maltese aircraft that wasn't spared an encounter with fire was a Constellation that once served as a restaurant. Arsonists torched it in 1997. Its engines and propellers sit in a lot next to the museum.

Visitors should also check out the small War Museum, housed in Fort St. Elmo in Valletta. Its most famous relic is the fuselage of *Faith*, the sole survivor of three Gloster Sea Gladiators that provided the island's only defense against the first attacks by the Italian air force. (The other two, naturally, were *Hope* and *Charity*.) But Polidano has hopes to get the famous biplane moved to his museum. "We've obtained two sets of incomplete wings for her," he says. *Faith* would then join the Spitfire and Hurricane in an Air Battle of Malta Memorial. The Malta Aviation Museum may be small, but it has big plans.

—Tom Huntington

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Boeing B-52 Stratofortress
B-52D: Max speed, 600 mph
Weapons load: 75,000 lbs
Engines: Eight Pratt & Whitney J57s
One of the most durable aircraft ever designed, the Stratofortress bombarded the North Vietnamese during Operations Linebacker I and II and the Viet Cong during Operation Arc Light.

Lockheed C-130 Hercules
C-130E: Max speed, 386 mph
Max takeoff weight: 175,000 lbs
Engines: Four Allison T56s
The C-130 hauled troops and supplies all over the theater and became famous for combat resupply missions, most notably at Khe Sanh.

Grumman A-6 Intruder
A-6A: Max speed, 685 mph
Weapons load: 15,000 lbs
Engines: Two Pratt & Whitney J52s
Marine Corps and Navy Intruders flew thousands of sorties from carriers to hit North Vietnamese targets. The A-6 could handle the foulest weather and still strike targets with amazing accuracy.

Bell UH-1 "Huey"
UH-1B: Max speed, 147 mph
Capacity: nine troops
Engine: Lycoming T53
The ubiquitous Iroquois, better known as the Huey, was used primarily by the Army and Marines for everything from troop miss by th boats

McDonnell F-4 Phantom II
F-4E: Max speed, 1,500 mph
Service ceiling: 62,250 ft
Engines: Two General Electric J79s
The legendary Phantom II was designed for the Navy and Marines as the F4H-1 but also became the premier Air Force fighter in Vietnam. The Phantom was used for bombing, reconnaissance, "Wild Weasel" radar jamming missions, and air-to-air combat.

Cessna L-19 (O-1) Bird Dog
O-1E: Max speed, 151 mph
Service ceiling: 18,500 ft
Engine: Continental O-471
A military version of the civilian Cessna 170, the Bird Dog was flown by forward air controllers just above, or slightly below, the treetops.

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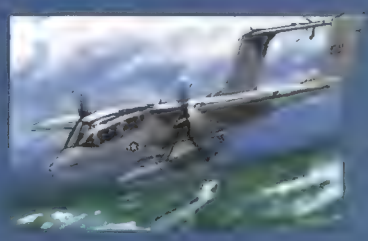
Lockheed C-141A Starlifter
The Air Force's first jet transport maintained the vital air bridge between Southeast Asia and the United States.

North American RA-5 Vigilante
Originally intended as a carrier-borne nuclear bomber, the Vigilante became an effective reconnaissance jet.

Douglas A-26 Invader
A World War II holdover, the Invader flew counter-insurgency missions and attacked supply routes and troop concentrations, often at night.



Rockwell OV-10 Bronco
The OV-10 provided a high-performance forward air control platform to the Air Force, Navy, and Marine Corps.

VIETNAM VETS

Significant Aircraft from the Vietnam War

ransport to gunship
ns. Huey gunships flown
Navy protected patrol
n the Mekong River.

s A-4 Skyhawk
ax speed, 673 mph
s load: 5,000 lbs
Pratt & Whitney J52
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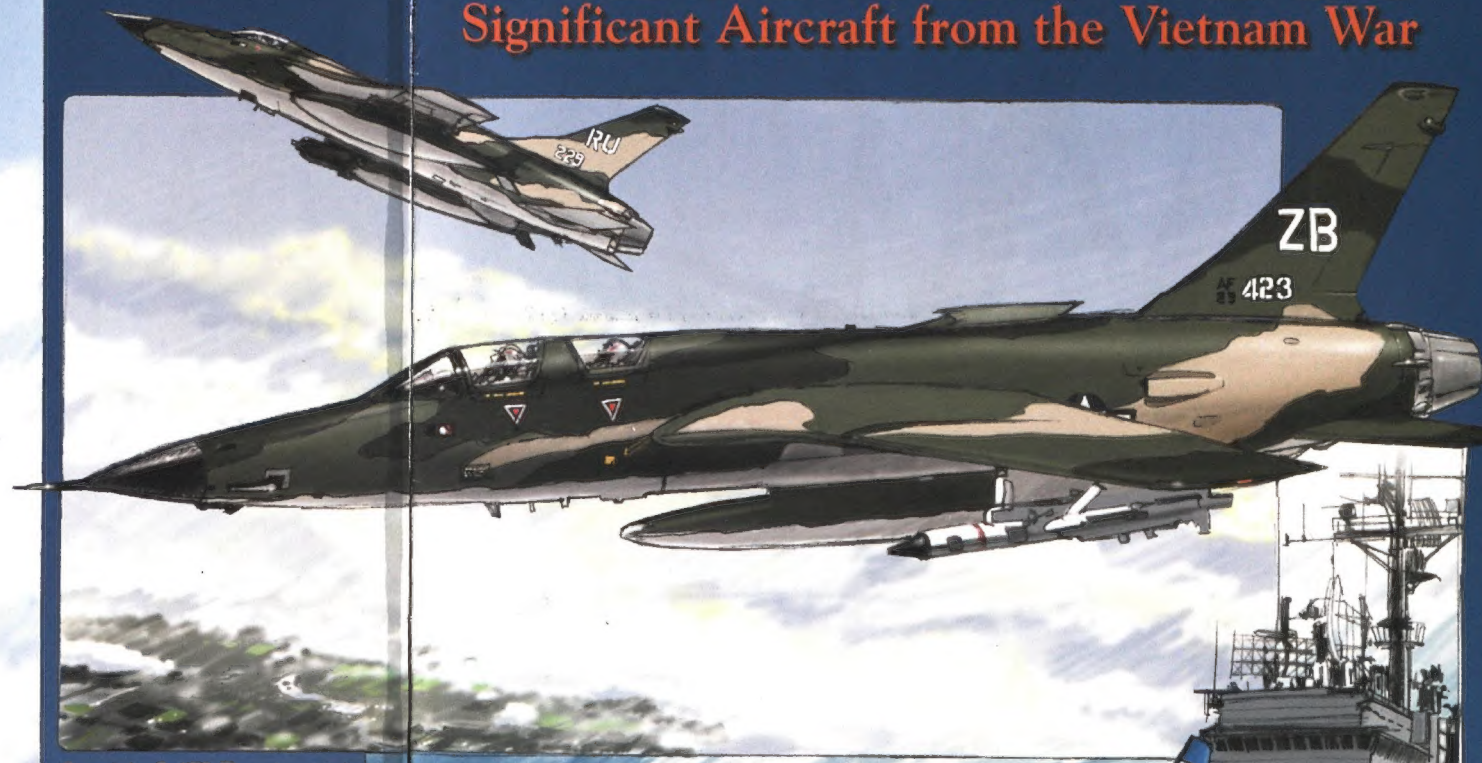
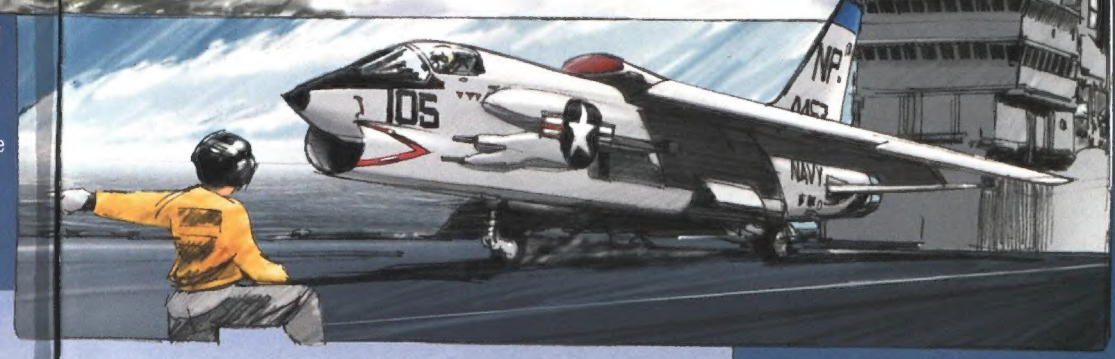


Republic F-105 Thunderchief
F-105D: Max speed, 1,390 mph
Weapons load: 14,000 lbs
Engine: Pratt & Whitney J75
Despite being designed to carry nuclear weapons, the F-105 became an effective conventional strike aircraft, but at high cost—more F-105s were lost in Vietnam than any other Air Force aircraft.



Sikorsky HH-3 "Jolly Green Giant"
HH-3E: Max speed, 164 mph
Capacity: crew of two or three
Engines: Two General Electric T58s
The HH-3 rescue version of the CH-3, fitted with an aerial refueling probe, armor plating, and a rescue hoist, replaced the HH-43 as the primary Air Force rescue helicopter in Vietnam.

Vought F-8 Crusader
F-8E: Max speed, 1,133 mph
Service ceiling: 52,350 ft
Engine: Pratt & Whitney J57
Called "the last of the gunfighters," the F-8 was a superb supersonic carrier-borne fighter used in the reconnaissance and fighter-bomber roles.

Douglas A-1 Skyraider
A-1H: Max speed, 321 mph
Weapons load: 8,000 lbs
Engine: Wright R-3350
The rugged "Spad" was flown by the Navy and Air Force for close air support and electronic countermeasures missions. Two Navy Skyraider pilots each shot down a MiG-17.

Douglas AC-47 "Spooky"
AC-47D: Max speed, 202 mph
Service ceiling: 29,000 ft
Engines: Two Pratt & Whitney R-1830s
The AC-47 could bring devastating firepower to bear on ground targets from the three 7.62-mm miniguns mounted in the fuselage. The concept was so successful it spawned the AC-119 "Shadow" and AC-130 "Spectre."

Boeing KC-135 Stratotanker
One of the longest serving aircraft in history, the KC-135 kept nearly every Air Force aircraft gassed up while flying missions over Vietnam.

Vought A-7 Corsair II
The Corsair II was built for the Navy, but the Air Force also flew the A-7 for ground attack and close air support.

Martin SP-5B Marlin
The last flying boat to serve in the Navy, SP-5s flew patrol missions from Cam Ranh Bay searching for North Vietnamese supply vessels.

Cessna AT-37 Dragonfly
A light attack version of the T-37 basic jet trainer, the AT-37 was flown extensively by the American and South Vietnamese air forces.

Fairchild C-123 Provider
The Provider was a rugged tactical airlifter that could drop into a dirt strip with ease.

Lockheed EC-121 Warning Star (Navy) College Eye (Air Force)
A military version of the elegant Constellation, the EC-121 provided airborne early warning.

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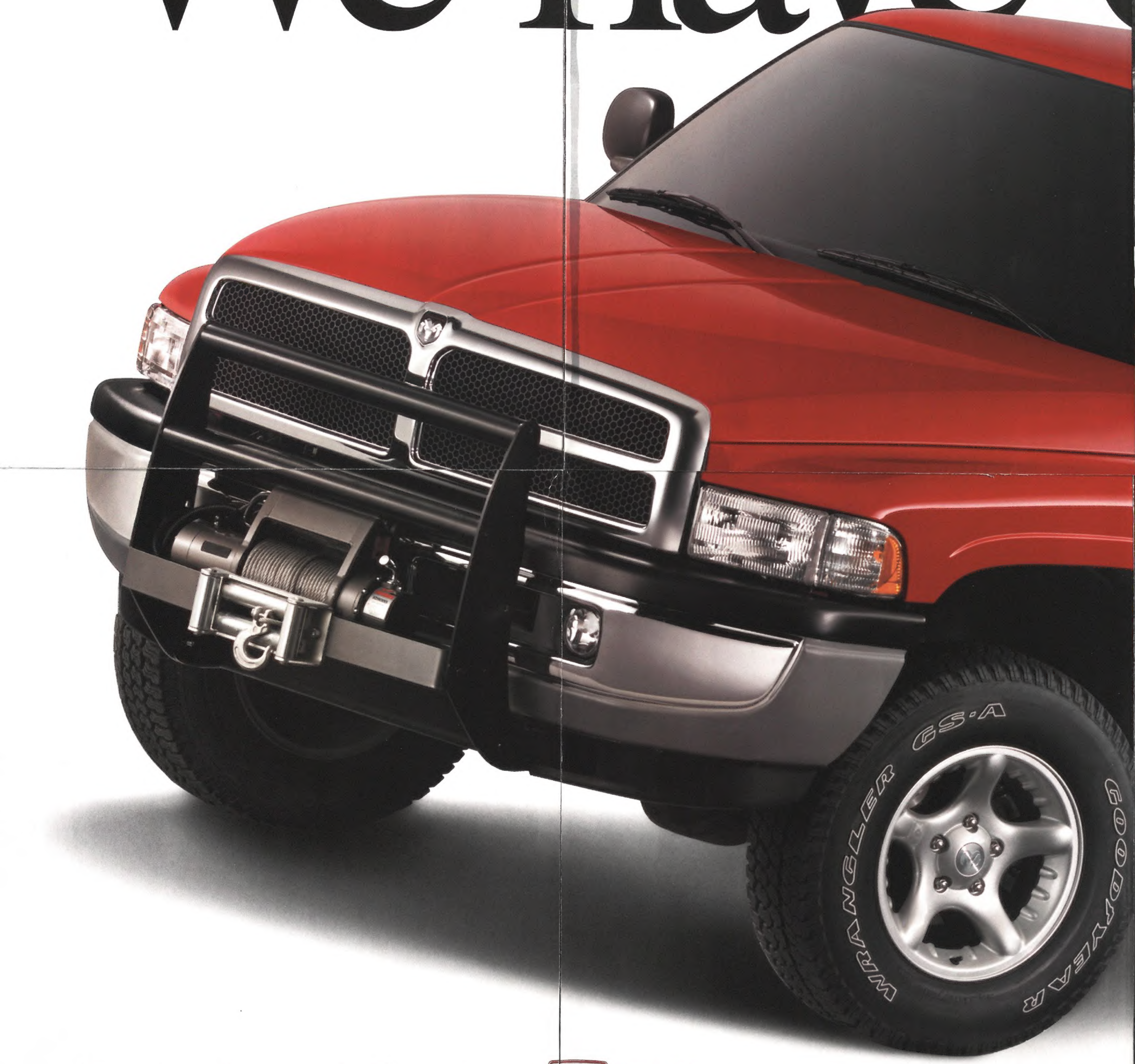

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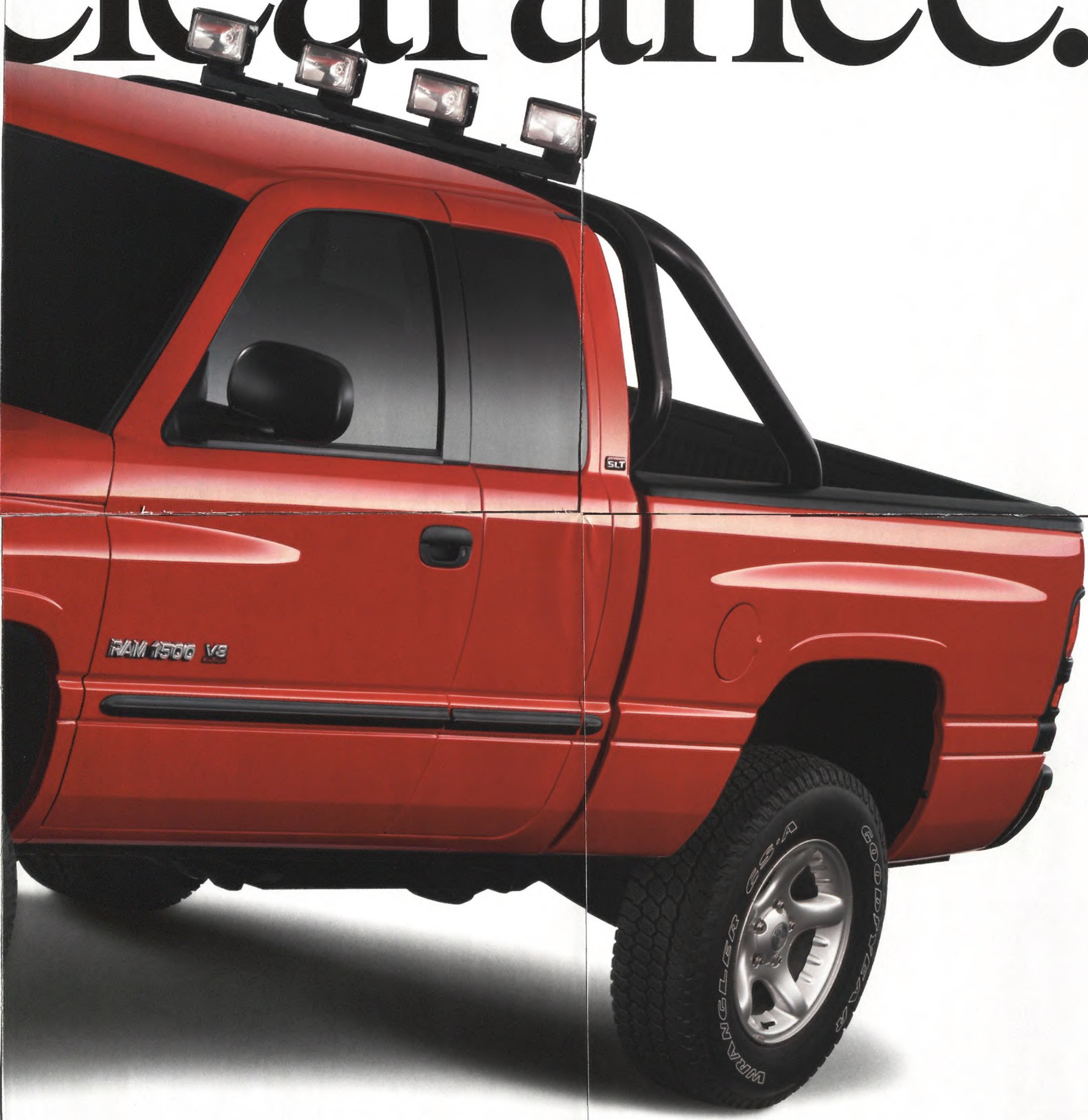
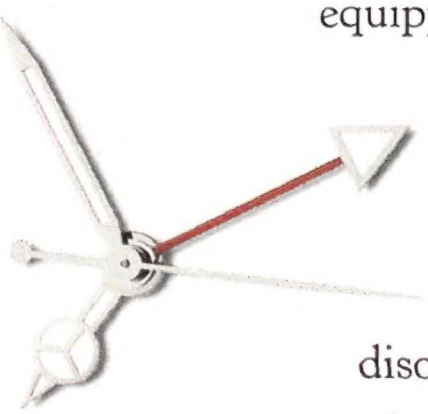


Even the most savvy travelers can use a helping hand.

For frequent international travelers, it can be more than a trifle challenging trying to juggle schedules in two different time zones. For these highly mobile executives, there's the Rolex GMT-Master II. This ruggedly handsome and dependable timepiece is



equipped with a supplementary 24-hour hand that enables a traveler to determine at a glance the time in a second time zone. This makes international travel a little less disorienting, and shows that for weary travelers four hands can be just the ticket.

Rolex Oyster Perpetual GMT-Master II in stainless steel with matching Oysterlock bracelet. For the name and location of an Official Rolex Jeweler near you, please call 1-800-36ROLEX. Rolex, ♛, Oyster Perpetual, GMT-Master II and Oysterlock are trademarks.

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